Cambridge English for

Engineering

TEACHER'S NOTES

UNIT 1 Technology in use

- Describing technical functions and applications
- Explaining how technology works
- Emphasising technical advantages
- Simplifying and illustrating technical explanations

Go to page 10 for essential background information and useful web links.

Refers to Student's Book pages

Before you begin **…**

Hold a short introductory discussion to kick off the course as a whole. Use the following questions to cue the discussion. In larger groups, students could work in pairs, or in groups of three or four.

- What field of engineering are you in / would you like to go into?
  Branches of engineering include: mechanical, electrical, civil, structural, process/ manufacturing, automotive, aeronautical, highway, coastal.
- How would you describe your branch of engineering to a non-specialist?
- What kind of work do you do / would you like to do within your field?
  Possibilities include: design, technical management/supervision/project management, product/process development, research, investigation/analysis/ trouble-shooting.
- In what kinds of situation do you / other people in your field need to use English at work?

To introduce *Cambridge English for Engineering*, invite students to look through the contents list and the book. Explain that the themes and situations, in terms of types of technology, companies and people, cover a wide range of different branches of engineering. Emphasise that although each example is specific, the *language* of each is useful to all types of engineer. Also explain that the main emphasis of the course will be on listening, speaking and *using* English actively in practice – through role plays and discussions, rather than learning lists of technical words.

Describing technical functions and applications

Language note

You will find the following vocabulary useful in this section.
use, use for …ing, use to (application), user, useful for …ing
enable to, allow to, prevent from, ensure that

1 a **Students complete the tasks in pairs. If they are struggling to come up with examples, you could suggest the following.**

mobile phones – phone calls, text messages, exchanging photos and videos, voice recording
electric drill/screwdriver handsets – for providing a turning force, drilling holes, putting in and removing screws, tightening and loosening nuts/bolts
hammers – for generating impacts, for driving in nails, hitting punches and chisels, breaking things

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b **Students complete the task in pairs.**

Extension activity: GPS

You could ask students the following question.
What do you know about the origins of GPS?

Answer

The system was originally developed for military use in the United States before being made available for civilian use internationally, with some limitations on its precision.

2 a ▶1.1 **Students listen and complete the notes.**

Answers

1 navigation
2 (monitoring) delivery vehicles
3 (finding) stolen cars
4 drift
5 man overboard
6 innovative uses of

b ▶1.1 **Students complete the extracts and listen again to check their answers.**

Answers

1 uses 2 use 3 user's; useful

Pronunciation focus

Ask students to identify the different pronunciation of s in the following words. Practise saying them.

a use /juːs/ *to use* /jːuz/ *useful* /juːsfəl/ *user* /juːzə/

3 a **Students match the applications and descriptions.**

Answers

2 d 3 b 4 f 5 a 6 e

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 3a (1–6) in more detail, as well as at related words.
surveying = recording the precise positions of natural features and structures, often in order to draw up maps or plans (a survey/a surveyor)
geological = related to the ground/rocks/soil (geology, a geologist)
civil engineering = the design and construction of large structures such as bridges, dams and skyscrapers, and infrastructure projects such as roads, railways and airports
avionics = electronic systems in aviation i.e. in planes and helicopters
maritime = related to the sea/shipping

b **Students complete the tasks in pairs.**

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4 a ▶ 1.1 **Students complete the extracts and listen again to check their answers.**

Answers
1 allows 2 prevents 3 ensures; enables

b **Students match the words and synonyms.**

Answers
1 allows/enables 2 ensures 3 prevents

c **Students complete the extract.**

Answers
1 allow/enable
2 allow/enable
3 ensure
4 allow/enable
5 prevent

5 **Give out Resource sheet 1a. Each student begins by writing down the name of the chosen product, and make notes of its main applications and functions. You may need to help with specific vocabulary. Students take turns to describe the applications and functions they have listed. To ensure the task is interactive, students should use the phrases in the box to sum up and rephrase what their partner has said.**

Explaining how technology works

Language note

You will find the following vocabulary useful in this section.
attach, fix, connect, link, support, carry, drive, power, propel, control, lift, raise, ascend, transport

6 a **Students discuss the questions in pairs.**

Before you begin …
Look at the meaning of the following terms.

space ship vs. *space station*
payload = meaning *load*, usually used in the context of space
environmentally unfriendly = opposite of *environmentally friendly*
orbital space = the height above which objects orbit the Earth, rather than falling rapidly back to earth
geostationary orbit = orbiting at the same speed as the Earth spins in order to remain above the same point, above the equator, on the Earth's surface
remote control = controlled from a distance

b **Students read the article and compare it to their answers in Exercise 6a.**

c **Students match the verbs and definitions, referring back to the article in Exercise 6b to see how the words are used in context.**

Answers
2 i 3 a 4 b 5 g 6 h 7 c
8 d 9 f

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Language note

Some of the verbs have more than one meaning:

fix
- to attach, for example fix with bolts
- to remain still, for example fixed above a point on earth
- to repair, for example fix a puncture

carry
- to withstand a load, for example the columns carry the roof
- to transport, for example the conveyor belt carries boxes

drive
- to control, for example the driver drives the car
- to propel, for example the engine drives the wheels

Before you begin …

Look at the meaning of the following terms.

strength-to-weight ratio

This is the strength of a material relative to its weight. Frequently, the stronger a material is, the heavier it is, and vice versa. For example, steel is strong and heavy, and polystyrene is light and weak. Materials with a high strength-to-weight ratio are both strong *and* light. The metal titanium is an example.

self-contained energy source

Cars have a self-contained energy source, as their fuel is carried on board in a fuel tank. Electric trains use an external energy source – their power is supplied by overhead electric cables.

wireless

Transmission by waves, without a direct wire link.

solar power Converting sunlight to electricity using photovoltaic panels.

7 a Students complete the notes.

b ▶1.2 Students listen and check their answers to Exercise 7a.

Answers

2 support
3 attached
4 raised
5 power
6 ascend
7 transport

c Students complete the task in pairs.

Answers

The notes are missing articles (a/an, the) and some auxiliary verbs (e.g. be).

8 a Check students' understanding of *offshore base station* = a station, at the bottom of the cable, which is located in the sea/ocean. Students complete the task in pairs.

b ▶1.3 Check students' understanding and pronunciation of *anchor* /æŋkə/.Students listen and answer the questions.

Answers

1 By a floating structure
2 To attach the base to the seabed
3 Ships would carry them.
4 Collisions between the cable and space debris
5 The anchors would be raised and the station would be moved.

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Before you begin ...
Look at the meaning of the following terms.

wind loads = the force of wind blowing against the cable horizontally and trying to push it sideways
propulsion system = system for making something move
propeller = device which causes a ship or aircraft to move, consisting of two or more blades which turn round at high speed

9 a Students analyse the notes in pairs and read them out in full.

Suggested answer

The anchoring system
The wind loads on the cable will be huge. What are the implications for the anchoring system? The base will need to be moved continually and sometimes urgently. What temporary system could be used to hold the base in position? Should the base be in shallow water near the coast, or in deep water further offshore? The choice will have an impact on the design of the anchor system.
The propulsion system
Will the weight of the cable allow the base to be moved by its own propellers or will a more powerful system for propulsion and control be required? For example, an external power source.

b Students complete the task in pairs and then compare their ideas to the suggested answers on page 96.

Suggested answers

Anchor system
It will be possible to anchor the base more securely in shallow water, near the coast. A permanent anchor structure could be built on the ocean bed, in shallow water. The base station could then be fixed securely to it with cables. If several anchor structures are built at different locations along the coast, the base station can be moved between them.
Propulsion system
Tugs (powerful boats used for pulling ships) could be used as an external power source. However, the base station could be driven by its own propellers. The large, powerful engines needed to propel it would be heavy, but that isn't necessarily a disadvantage, as extra mass, and therefore extra inertia, would help to make the base more stable.

c Students complete the task in small groups.

d Students complete the task either in class or as a homework activity.

Emphasising technical advantages

Language note

You will find the following vocabulary useful in this section.
conventional, eliminate (problems), superior (quality), (energy-)efficient, enhanced, reduce
completely, significantly, dramatically, entirely, highly, extremely, considerably, totally, exceptionally

10 Students complete the task in pairs.

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Extension activity: brand superiority

Ask students which brands have a reputation for technical superiority / high quality in the following areas.

- electrical kitchen appliances (refrigerators, ovens, dishwashers, etc.)
- power tools (electric drills, power sanders, angle grinders, etc.)
- hand tools (hammers, saws, screwdrivers, etc.)
- digital cameras
- vehicle tyres
- performance cars

You could extend the discussion to explore the issue of price. Is the higher cost of some brands justified in terms of quality and durability?
Do any other brands offer better value for money, in terms of quality / technical superiority versus cost?

Before you begin ...
You could ask students the following question.

Who are Otis?

Answer

They are an American-based, multinational manufacturer of lifts/elevators.
Otis were pioneers of elevators in the mid-19th century.

11 a Students read the text and answer the question.

Answers

It's a flat belt for lifting elevators which is used instead of a cable.
Compared with cables, the Gen2 system has a number of advantages.

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 11a in more detail.
belt = a *drive belt* – belts can have a flat or V-shaped section
cable = a rope made of metal wires – when used for lifting it is also called a *wire rope*
coated = surrounded by another material – *a coating*
crowned machine sheave = a *sheave* is a wheel used in association with a belt, often called a *pulley*; *crowned* – describes the section of the wheel, meaning it has a ridge at either side to prevent the belt from coming off
hoistway = a vertical shaft inside a building which houses a lift (British English – *lift shaft*)

b Students match the words and synonyms.

Answers

2 e 3 b 4 f 5 c 6 a

c Students complete the extract.

Answers

2 reduces
3 conventional
4 reduce
5 enhance
6 conventional
7 superior
8 eliminates

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Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 11c in more detail.
gearless = has no *gears* – *gears* are *cogwheels* which mesh together to transfer drive from one wheel to another
wear = progressive degradation due to normal use, for example vehicle tyres
cords = *wires*
machine room = a room in a building where machines, such as lift machinery, air-conditioning units and water pumps are located – also often called a *plant room*, *plant* being an alternative collective term for *machines*

d **Students complete the task in pairs.**

12 **a** **Students complete the tips.**

Answers

1 enhanced
2 reduced
3 eliminated
4 conventional
5 superior

b ▶1.4 **Students listen and match the tips to the extracts.**

Answers

1 c 2 b 3 a 4 d

c **Students complete the task and then listen again to check their answers.**

Answers

2 dramatically
3 entirely
4 extremely
5 considerably
6 highly
7 exceptionally
8 significantly

d **Students match the words and synonyms.**

Answers

1 entirely; totally
2 considerably; dramatically
3 exceptionally; highly

13 **Students complete the task in pairs.**

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Extension activity: lift design (Resource sheet 1b)

Give students Resource sheet 1b. Students describe the advantages of lift technology in pairs.

Suggested answers

1 This eliminates the risk of someone being trapped inside the lift and being unable to call for help.
2 This reduces the temperature inside the lift during hot weather and offers superior comfort.
3 This reduces waiting time, making the operation of the lifts more efficient by allowing them to share the work. For example, if someone has called the lift on the third floor and both lifts are ascending, the first lift can stop at the third floor, while the second lift continues, without stopping, to a higher floor (provided nobody already inside it has selected the third floor).
4 This means each lift has a shorter maximum travel distance, reducing waiting times. Although people travelling the full height of the building have to change lifts at mid-height, this inconvenience is outweighed by the superior overall performance of the split-level system.
5 The 4-door system allows the doors to open twice as fast, enhancing entry and exit speeds.

Simplifying and illustrating technical explanations

Language note

You will find the following vocabulary useful in this section.
in simple terms, put simply, in other words, basically, effectively, essentially, what we call … , what we refer to as … , if you imagine … if you picture … jargon

14 a ▶1.5 **Students listen and answer the questions.**

Answers

1 That you shouldn't use jargon or it will sound like nonsense and that technical concepts can be difficult to explain, even using everyday language
2 Explanations that are boring
3 Speaking to an adult as if you're talking to a child

b Students complete the task in pairs.

c ▶1.6 **Students listen and compare the points made with their answers in Exercise 14b.**

15 a Students discuss the technical terms and try to interpret the jargon.

b ▶1.7 **Students listen and make notes and then compare Richard's explanations with their own ideas from Exercise 15a.**

c ▶1.7 **Students listen again and compare the techniques Richard uses to simplify and illustrate the technical terminology with the tips in Exercise 14c.**

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d **Students complete the table.**

Answers

1 put simply; in other words; basically
2 effectively; essentially; basically
3 what we call; what we refer to as
4 if you imagine; if you picture

e **Students complete the task in pairs.**

16 **Students rephrase the description. This could be prepared as a written exercise with students then reading out their explanations to the group.**

Suggested answer

There are two types of pile foundation: end-bearing piles and friction piles. Essentially, end-bearing piles are used when you have soft ground which is on top of hard ground or rock. Basically, the piles go through the soft ground and sit on the hard ground below. It's a bit like building over water. The soft ground is like water, which can't support anything, and the hard ground below it is like the seabed. Put simply, the piles are like stilts. Friction piles are different. They're used when there's no hard ground. In simple terms, the sides of the pile grip the soft ground around them. If you picture a nail in a piece of wood, it's the same thing. The nail is gripped by the wood around it. Sometimes the bottoms of friction piles are made wider. Imagine a leg with a foot at the bottom, it's the same principle.

17 **You could give students Resource sheet 1c to prepare individually. Students complete the task in pairs, taking it in turns to be the guided tour host and visitor. Although the items of technology being explained will not be visible, the student who is listening should try to picture what is being described, and should regularly rephrase their partner's explanations, to check understanding.**

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Background information and useful web links

Cambridge English for Engineering is designed to be used by engineers, technicians and technical managers from all branches of engineering. The three main branches are:

- **mechanical engineering** ñ the design and production of machines, for example engines, pumps, vehicle chassis, automated production lines
- **electrical engineering** ñ the design and assembly of electrical circuits and components, for example power supply networks, electrical controls for automated machines, electrical systems in vehicles
- **civil/structural engineering** ñ the design and construction of large structures, for example skyscrapers, bridges, dams, tunnels.

There are also many more specialised branches of engineering, for instance, manufacturing/process engineering (production lines / manufacturing plants), automotive engineering (vehicles), aeronautical engineering (aircraft).

The specialised disciplines of engineering, and specific engineering projects, often draw on two or more of the main branches. For example, cars and planes contain both mechanical and electrical systems requiring mechanical and electrical engineers to collaborate closely. Similarly, the design and construction of new power stations requires intricate coordination between mechanical installations, for example turbines, electrical equipment, for example generators and the civil engineering structures that support and house them.

The fact that there is so much interfacing between engineering specialisations means that, beyond the highly specific terminology of their own field, all engineers need to speak the same general technical language, and possess the language skills commonly used in technical conversations. *Cambridge English for Engineering* teaches this type of language.

Describing technical functions and applications (pages 6 and 7)

This section deals with language for describing what appliances do and what they are typically used for. The theme – global positioning systems (GPS) – represents a well-known area of technology with a wide range of applications. The language covered is relevant to describing the purpose of any technological application, whether an individual component or a complex assembly in an electrical device or installation, a mechanical assembly, a structure, a section of a production line, etc.

GPS
http://en.wikipedia.org/wiki/GPS

Explaining how technology works (pages 8 and 9)

This section focuses on verbs commonly used for describing how technology works in general terms.

Space elevators
http://www.spaceelevator.com
http://www.howstuffworks.com/space-elevator.htm

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Emphasising technical advantages (pages 10 and 11)

This section reflects the importance of constant technical improvement and innovation in a commercially competitive environment, a concept which is at the heart of all branches of engineering. The underlying aim is to help students emphasise technical advantages, and to sell their ideas, whether to clients, superiors or colleagues. The theme – cutting-edge lift technology at Otis – provides both modern and historic interest in terms of promoting technological progress.

Lifts
http://en.wikipedia.org/wiki/Elevator
http://www.youtube.com/watch?v = LblD4i2Dq4w
http://www.youtube.com/watch?v = DkWkgoeLZzU&feature = related
http://www.youtube.com/watch?v = wOacMrrieh4&feature = related

Simplifying and illustrating technical explanations (pages 12 and 13)

Engineers who specialise in specific technical fields often liaise with colleagues from other branches of engineering, and frequently have to deal with generalist project managers, and non-technical superiors and customers. In such cases, it is essential to be able to explain and illustrate technical concepts in clear, simple terms. This section focuses on this important skill. It should be noted that the specialised terms for describing pile foundations in this section are dealt with, not as target language, but to exemplify the phrases and techniques used for simplifying and illustrating technical terminology.

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UNIT 1 Technology in use

Resource sheet 1a

Make notes on the product you have chosen to help you describe it to your partner.

Name of product	Application (what the product is used for)	Functions and features (what the product does and has)
Useful language	*The product's main use is ...* *The main users of the product are ...* *The product is used to ...* *It's used for ...ing* *It's useful for ...ing*	*(The product) enables you to ...* *(The product) allows you to ...* *(This feature) ensures that ...* *(This feature) prevents ... from ...ing*

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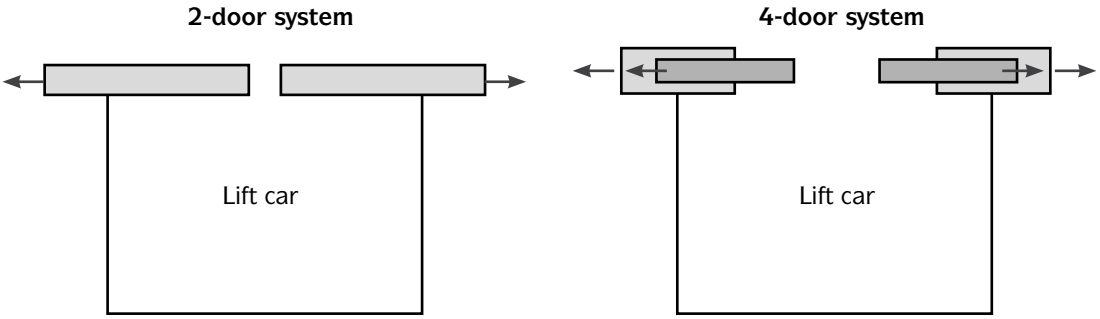
UNIT 1 Technology in use

Resource sheet 1b

The concepts below have been introduced over the years to enhance the operation of lifts. With a partner, describe the advantages offered by each system.

1 Equip the lift car with an alarm button and an intercom system.
2 Equip the lift car with air-conditioning.
3 Instead of installing one large lift, install two smaller lifts, side by side, which run independently but are both managed by the same call buttons in the lobby on each floor of the building.
4 In very tall buildings, instead of having lifts which run the full height of the building, have two levels of lifts, with the first level serving the bottom half of the building, and the second level serving the top half.
5 Instead of using a system of 2 sliding doors, 4 sliding doors are used, as below.



Useful language
This enhances ... This reduces ... This eliminates ... This offers superior ...

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UNIT 1 Technology in use

Resource sheet 1c

Make notes on the product or type of technology to help you describe it to your partner.

Technology	Function	Comparison with an everyday concept
Useful language	This is what we call a ... This is what we refer to as a ... Basically/Effectively/Essentially , it's (like) a ... In other words ... In simple terms ... Put simply ... If you imagine a ... If you picture a ...	

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UNIT 2 Materials technology

- Describing specific materials
- Categorising materials
- Specifying and describing properties
- Discussing quality issues

Go to page 25 for essential background information and useful web links.

Describing specific materials

Before you begin …
Ask students to suggest some examples of materials widely used in engineering. Ask students what is meant by *recycling*. How does recycling affect engineering design?

Answer
Increasingly, engineers need to *design in* recycling – planning for how assemblies will be disposed of.

Language note
You will find the following vocabulary useful in this section.
aluminium, bronze, copper, glass, lead, iron, ore, plastic, rubber, steel, stainless steel, timber, hardwood, softwood, zinc

1 **Students complete the task in pairs.**

Suggested answers

Scrapping cars
A lot of metal, notably steel, can be recycled. Intact parts can be recovered and resold. Oil, brake fluid and battery acid are potential pollutants which need to be disposed of carefully. Tyres are more difficult to recycle.

Recycling electronics
Heavy metals such as lead, cadmium and chromium are potential pollutants and can also be recovered for recycling. The process of recycling electronic products is quite difficult due to the difficulty of breaking up and separating very small components.

Breaking up ships
Large amounts of steel can be recovered and recycled. Main pollutants are fuel oil from tanks and asbestos which was widely used as an insulation material inside ships.

Demolishing buildings
Structural steel can be recycled, concrete can be crushed and reused, for example in asphalt for road surfacing, copper in electrical wires can be recovered and recycled, good-quality bricks can sometimes be cleaned and reused. As with ships, asbestos is often found, requiring special precautions for its removal. The main difficulty is the time taken to demolish buildings meticulously.

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2 a **Students complete the headings.**

Answers

2 Glass
3 Copper
4 Aluminium
5 Timber
6 Rubber
7 Plastic

Language note

British English = aluminium /æljʊmɪniəm/ American English = aluminum /əlumɪnəm/

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 2a in more detail.
magnetism = force of attraction
galvanised = coated with zinc (Zn) to prevent rusting
recyclable = can be recycled
chromium (Cr) and nickel (Ni) = metals added to steel to make stainless steel
traces = small quantities
scarcity = limited availability/rarity
insulation = both electrical insulation and thermal insulation
wire = single strand of metal
scrap = waste material intended for recycling
alloy = a mixture of metals sometimes containing a non-metal, for example carbon (C) in steel
brass = an alloy of copper (Cu), zinc and, often, lead (Pb)
bronze = an alloy of copper and tin (Sn)
melting down = using heat to change the state of a substance from solid to liquid
energy-intensive = using a lot of energy
electrolysis = passing an electrical current through a liquid or solid in order to separate chemical compounds
ore = mineral from which metal is extracted
hardwood = timber from deciduous trees
softwood = timber from pine trees
ironmongery = collective term for small metal items commonly used in buildings, for example door handles, hinges, screws, nails

b **Students match the words and definitions.**

Answers

2 a 3 b 4 f 5 d 6 h 7 e 8 g

Extension activity: pronunciation

Give students Resource sheet 2a and ask them to decide whether the sounds of the sections in bold are the same or different. Check the pronunciation together.

Answers

2 ore; or = same
3 stainless /ləs/ steel; less /les/
4 galvanised /ˈgælvənɑɪzd/;van /væn/
5 wood /wʊd/; food /fuːd/
6 zinc; think = same
7 nickel /nɪkəl/; well /wel/
8 chromium /ˈkrəʊmiəm/; from /frɒm/
9 lead /led/; lead /liːd/

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c **Students complete the sentences.**

Answers

2 with
3 from
4 from
5 with
6 of
7 of
8 from

d **Students complete the task in pairs. Students could focus on the materials mentioned on the webpage on page 14, or other familiar materials. You could give students Resource sheet 2b for extra help.**

3 **a** **Check students' understanding of *environmentally friendly design* (= designing with environmental protection in mind), for example recycling, energy efficient, avoiding pollution. Students discuss the ideas in pairs.**

b ▶2.1 **Students listen and complete the task.**

Answers

The main point that Irina makes is that it's important to consider the total environmental impact of a product, including producing it (pre-use), using it (in-use) and recycling it (post-use). She gives the example of an energy-saving light bulb.

c ▶2.2 **Students listen and make notes.**

Answers

Sophia and Pete's ideas:
Pre-use: aluminium production (extraction from ore and recycling), coating steel (galvanising), transporting and handling bulk material, cutting and welding
In-use: weight (impact on fuel consumption), lifespan (frequency of manufacturing)

d **Students complete the task in pairs. Students could look at audioscript 2.2 for extra help and use the conversation as a model.**

Suggested answers

Electrical wires in vehicles
For pre-use, as far as I know, it takes more energy to produce aluminium than to produce copper, if it's derived from ore. However, it takes less energy to transport aluminium, because it's lighter.
For in-use, I'm sure aluminium is better because it's lighter, so the vehicle would consume less fuel.
For post-use, both aluminium and copper can be recycled. I'd say it takes less energy to handle and transport aluminium, because it's lighter.
External walls in houses
For pre-use, it takes a lot of energy to produce bricks because they have to be fired in a kiln. They're also heavy to transport. Softwood is lighter to transport, and I'd say it probably takes less energy to saw it and handle it, compared with making bricks. During construction, building with bricks uses more energy, as sand and cement have to be transported and mixed to make mortar.
For in-use, wood is a better insulator than brick which is an advantage, as the house should take less energy to heat. In theory, softwood could last as long as bricks, if it's properly maintained. But in practice, that will often not be the case. So, construction energy could sometimes be higher for softwood, as houses need to be rebuilt more often.
For post-use, it's possible to recover both bricks and softwood for re-use, but neither is very easy to recycle.

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Categorising materials

Language note

You will find the following vocabulary useful in this section.
compound, exotic (material), ferrous, non-ferrous, ceramic, alloy, metallic, non-metallic, polymer
consist of, comprise, made of, made from, made out of

Before you begin …
Ask students to explain what is meant by *categorising materials* (= putting materials into different categories/types). Ask students to give some examples of different categories of materials and one or two specific materials to illustrate each category, for example metals – steel and copper.

4 **Students complete the task in pairs.**

Suggested answers

1 Brakes are designed to slow down vehicles or moving parts. Often they work through friction, by applying pressure to pads which are pressed against the sides of a disc, the inside of a drum, or directly against a wheel rim. Alternatives include systems that use electromagnetic force, systems that exploit the braking effects of engines or flywheels (via clutches and gearboxes), aerodynamic braking systems (for example spoilers on aircraft, parachutes on dragsters), and reverse thrusters on jet engines. Brake discs are often made of ferrous metals (iron-based – for example steel), or sometimes ceramic materials.
2 Examples of materials used to make pads include: compounds of advanced materials (cars), ferrous metals (trains), rubber (bicycles), ceramics (performance cars).

5 a **Students read the article and answer the question.**

Answers

Green refers to ecological issues. Red refers to heat (*red hot* means very hot). Also, a *hot topic* is a current important topic.

b **Students complete the task in pairs.**

Answers

1 Because they use friction, which wastes energy as heat
2 They recover heat and use it to power the car.
3 The ability to generate high levels of friction, and to resist the effects of friction and consequent heat
4 Heat from the engine being absorbed by the chassis, which can damage sensitive parts such as electronic components and plastic parts

c **Students match the materials and descriptions.**

Answers

2 g 3 b 4 f 5 d 6 a 7 e

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Extension activity: metals (Resource sheet 2c)

Give students Resource sheet 2c. Students complete the table in pairs.

Answers

Metals: bronze, copper, iron, steel
Alloys: bronze, steel
Non-metals: glass, nylon, synthetic rubber
Ferrous metals: iron, steel
Non-ferrous metals: aluminium, bronze, copper
Polymers: nylon, synthetic rubber
Ceramics: glass

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 5a in more detail.
automotive = related to vehicle design and manufacturing
kinetic energy = energy in the form of movement, for example a spinning wheel
deceleration = reducing speed
acceleration = increasing speed
asbestos = a fibrous material derived from rock that was used as an insulating material; it is no longer used as it damages the lungs if the fibres are inhaled
composite = combined materials, consists of a bulk material called a matrix, reinforced with fibres or bars, for example glass-reinforced plastic = plastic matrix with glass fibres
non-hazardous = not dangerous
exhaust = system for evacuating smoke or gases, for example from an engine

d **Students complete the task in pairs.**

6 a **Students complete the task.**

b **Students complete the task in small groups.**

Before you begin ...
Look at the meaning of the following terms.

insulation = a protective material which does not conduct electricity
waterproof membrane = thin layer of material which acts as a barrier to prevent water passing
armoured = covered with a very strong protective layer
conductor = material which conducts electricity

c **Students complete the task.**

d ▶2.3 **Students listen and check their answers to Exercise 6c.**

Answers
1 c 2 b 3 d 4 a 5 e

e **Students match the parts of the cable and the materials. Students can use audioscript 2.3 for extra help.**

Answers
1 b; c 2 d; e 3 d 4 e 5 a; b; c

7 **Students complete the task in pairs or small groups.**

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Specifying and describing properties

Language note

You will find the following vocabulary useful in this section.
elasticity, toughness, abrasion resistance, thermal stability, lightweight, durable ideally, obviously, the key requirement, the last thing you want is …, a good degree of …

Before you begin …
Ask students to explain what is meant by *properties of materials* and to give some examples of properties of specific materials, for example steel (*tough*), polystyrene (*lightweight*).

8 a **Students complete the task in pairs.**

b **Students read the article in pairs and compare their answers in Exercise 8a.**

c **Students find the words in the text to match the definitions.**

Answers
2 abrasion resistance
3 thermal stability
4 durable
5 lightweight

Extension activity: adjectives and nouns (Resource sheet 2d)

Give students Resource sheet 2d. Students complete the table in pairs. You could also look at *rigid* and *rigidity*, as opposites of *elastic/flexible, elasticity/flexibility*.

Answers
1 toughness
2 elastic; elasticity
3 abrasion-resistant; abrasion resistance
4 thermally stable; thermal stability
5 durable; durability
6 light; lightness
7 fragile; fragility
8 flexible; flexibility
9 heavy; heaviness
10 brittle; brittleness
11 rigid; rigidity

9 a **Students match the automotive parts and descriptions.**

Answers
1 c 2 e 3 b 4 a 5 d

b **Students complete the extract.**

Answers
1 tyres
2 drive belts
3 brake pads
4 bullet-resistant armour
5 sealing gaskets

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c **Students complete the task in pairs.**

Suggested answers

In tyres, puncture and tear resistance help to stop punctures and blowouts and abrasion resistance helps the tyre to last longer. In drive belts, high elasticity allows belts to fit tightly and abrasion resistance helps them resist the friction caused by the belt turning. In brake pads, abrasion resistance helps the pads to last longer and thermal stability helps them resist the heat generated during braking. Kevlar® helps make bullet-resistant armour, which is generally heavy, more lightweight, which is better for the vehicle's performance. Kevlar® makes sealing gaskets durable and its thermal stability allows them to resist heat – for example, in engine cylinder heads – and its chemical stability means gaskets are not affected by engine fluids such as fuel, lubricating oil and coolant liquids.

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 9b in more detail.
puncture (n) = hole causing a leak of air or liquid, for example in a tyre
tear /teə(r)/ *resistance* = resistance to tearing (a sheet of material being pulled apart)
tension = a stretching force
revolution = one turn of something, a wheel for example
lifespan = the length of time for which a person, animal or thing exists – this also describes how long mechanical components last
frictional forces = resistance when two surfaces rub together
pulp = a mass of small particles or fibres, mixed together
handling = how a vehicle responds to control inputs from the driver, for example to steering, throttle and brakes when it is driven
chemical stability = resistance to damage from chemical substances
galvanic corrosion = corrosion caused when two different types of metal are in direct contact with each other

10 **a** ▶2.4 **Students listen and answer the questions.**

Answers

1 At the dentist's
2 The tool is a dental drill.
3 Titanium can be used for the handle, and tungsten-carbide and diamond for the bur.

b ▶2.4 **Students complete the extracts and then listen again to check their answers.**

Answers

1 lightweight
2 abrasion resistance
3 durable
4 thermal stability

c **Students match the words and phrases and the synonyms.**

Answers

1 b 2 a 3 e 4 c 5 d

Before you begin …
Discuss what is meant by *hand tools* (= tools that are held in the hand and are not powered). Ask students to give some examples of hand tools, for example hammer, saw, screwdriver, pliers.

11 **a** **Students complete the task in pairs.**

b **Students complete the task in pairs.**

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Discussing quality issues

Language note

You will find the following vocabulary useful in this section.
water-resistant, corrosion-resistant, shock-resistant, abrasion-resistant, resistance
extremely, exceptionally, tremendously, quite, fairly, pretty, relatively, not very, not particularly, not (all) that, insufficiently, not adequately, not at all

Before you begin …
Ask students to explain what is meant by *quality* and to give some examples of technical products/brands, for example cars, work tools, mobile phones, or TVs, that have a reputation for good quality. What makes the products stand out from the competition? Why are they better from a technical standpoint? You could also ask students to explain what is meant by *value for money* and bring the issue of cost into the discussion. For the products mentioned, are prices significantly higher? Is higher quality worth a higher price?

12 **Students answer the questions in pairs.**

Suggested answers

1 Examples of situations used in advertising include motor racing, water sports such as surfing and diving, and aviation.
2 The intended message is that watches are accurate and are resistant.
3 Higher quality watches keep good time; are resistant to water and shocks; and are made from more expensive, better-looking materials.
4 Describing something as water-resistant suggests it can resist water up to a certain limit, for example to a certain depth or pressure. Describing something as waterproof suggests it gives unlimited protection from water.

13 a ▶2.5 **Students listen and complete the notes.**

Answers

1 corrosion resistance
2 water resistance
3 scratch resistance
4 shock resistance

b **Students complete the task in pairs.**

Extension activity: more vocabulary

You could look at the following terms and discuss the difference between *resistant* and *retardant*. Some materials cannot resist the effects of flames indefinitely and therefore only have a *retarding* [delaying] effect. Ask students to think of examples for each one.
chemical-resistant heat-resistant fire-resistant flame-retardant

14 a ▶2.5 **Students listen to the recording again and answer the questions.**

Answers

1 Watch materials are sometimes chosen for marketing reasons, not technical reasons.
2 They considered using submarine-grade steel in some models even though water resistance actually depends on the joints and seals, not the metal used.
3 Many good watch-making materials are either ordinary, or complex, and so are not very marketable.
4 Consumers are not technical experts, and make choices based on their impressions, rather than on factual information.

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b **Students complete the task in pairs.**

Answers

1 T
2 T
3 F – it needs a protective coating.
4 F – he says it's fairly poor in terms of looks.
5 F – no – for the reasons given above.
6 F – inadequate materials have never been chosen for marketing reasons.
7 T
8 F – complicated names are not good for marketing.

c ▶2.6 **Students listen and underline the stressed syllable.**

Answers

2 exceptionally resistant
3 not at all suitable
4 tremendously marketable
5 relatively complex
6 not all that good

d **Students complete the table.**

Answers

1 extremely, exceptionally, tremendously
2 quite, fairly, pretty, relatively
3 not very, not particularly, not (all) that
4 not enough, insufficiently, not adequately
5 definitely not, not at all

Extension activity: marketability

Ask the students to give their views on how marketable the following materials are.
steel stainless steel cast iron titanium plastic aluminum/aluminium concrete copper
Encourage them to use language from Exercise 14d. Since the answer depends partly on the application in question, discuss examples of products and uses where some of the materials are viewed positively by customers.

15 **Students complete the task in pairs.**

Suggested answers

Steel is relatively heavy and very tough. It is pretty scratch-resistant and shock-resistant. Mild steel is not very corrosion-resistant but stainless steel has good corrosion resistance and is therefore suitable for watches. Glass is quite heavy and is water-resistant and corrosion-resistant. Ordinary glass is very brittle and has fairly poor shock resistance and scratch resistance, although it is still suitable for watches. Toughened glass is more durable. Aluminium is relatively lightweight and is fairly tough. It has good corrosion resistance. It is therefore suitable for watches. Titanium is exceptionally lightweight and tough and has excellent abrasion resistance. It is also extremely corrosion-resistant and is therefore an excellent watch material. Gold is extremely heavy and pretty tough, although softer grades of gold have quite poor shock resistance and scratch resistance. Gold has excellent corrosion resistance. It is suitable for more expensive, decorative watches.

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16 Students complete the task in small groups.

Extension activity: the company's products

If your students are in work, you could ask them to talk about the quality of their company's products compared with those of the competition. This could include the issue of cost, and also *perceived quality*. Are customers' perceptions of the company's products accurate?

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Background information and useful web links

Describing specific materials (pages 14 and 15)

This section focuses on commonly used engineering materials. This topic is central to all branches of engineering as any given branch of engineering uses a wide range of different materials. The context of recycling reflects the increasing importance of environmental considerations in engineering design.

Categorising materials (pages 16 and 17)

This section extends the topic of materials by looking at categories of engineering materials. The language is useful for understanding and describing the vast array of materials used in modern technology, such as conductors, insulators and semi-conductors in electrical engineering, and composite materials and alloys in mechanical and civil engineering.

Specifying and describing properties (pages 18 and 19)

This section deals with the physical properties of materials, from the point of view of describing properties, as well as specifying what properties are required/desirable for a given application. In all fields of engineering, materials are selected for their specific properties. Specifying required properties is therefore central to engineering design.

Kevlar
http://www2.dupont.com/Kevlar/en_US/
http://www2.dupont.com/Kevlar/en_US/assets/downloads/KEVLAR_Technical_Guide.pdf

Discussing quality issues (pages 20 and 21)

In dealing with the topic of quality, this section covers language for describing degree (*exceptionally*, *not particularly*, etc.) This provides a skill-based extension of the previous section, allowing the properties of materials to be qualified (*exceptionally tough, not particularly durable,* etc.)

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UNIT 2 Materials technology

Resource sheet 2a

Are the sounds in bold the same or different?

			the same	different
1	st**ee**l	st**ea**l	☑	☐
2	**ore**	**or**	☐	☐
3	stainl**ess** steel	l**ess**	☐	☐
4	gal**van**ised	**van**	☐	☐
5	w**oo**d	f**oo**d	☐	☐
6	z**inc**	th**ink**	☐	☐
7	nick**el**	w**ell**	☐	☐
8	ch**rom**ium	**from**	☐	☐
9	l**ea**d (metal)	l**ea**d (be ahead)	☐	☐

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UNIT 2 Materials technology

Resource sheet 2b

Material	Made from	Recyclable?
Steel	Iron (from iron ore) Carbon (from coal)	Yes – can be melted down and iron recovered for reuse
Natural rubber	Latex (from trees)	Not easily – tyres can be ground into crumbs (small lumps) for use in other materials
Glass	Silicon (from sand)	Yes
Bronze	Copper (from copper ore) Tin (from tin ore)	Yes – can be melted down and metals separated
Brass	Copper (from copper ore) Zinc (from zinc ore)	Yes – can be melted down and metals separated

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UNIT 2 Materials technology

Resource sheet 2c

Complete the table using the materials in the box. You will need to use each material more than once. Add any other examples you can think of.

~~aluminium/aluminum~~ bronze copper glass iron nylon steel synthetic rubber

Material category	Examples of specific materials in the category
Metals	aluminium/aluminum
Alloys	
Non-metals	
Ferrous metals	
Non-ferrous metals	
Polymers	
Ceramics	

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UNIT 2 Materials technology

Resource sheet 2d

Complete the table with adjectives and nouns. Underline the stressed syllables.

	Adjective	Noun
1	tough	toughness
2	elastic	
3		resistance
4		stability
5	durable	
6	light	
7		fragility
8	flexible	
9	heavy	
10	brittle	
11	rigid	

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TEACHER'S NOTES

UNIT 3 Components and assemblies

- Describing component shapes and features
- Explaining and assessing manufacturing techniques
- Explaining jointing and fixing techniques
- Describing positions of assembled components

Go to page 39 for essential background information and useful web links.

Describing component shapes and features

Language note

You will find the following vocabulary useful in this section.
layout, laid out, profile, configuration
circular, rounded, rectangular, cylindrical, linear, triangular
The nouns and adjectives are usually different (a rectangle / a rectangular shape, a cylinder / a cylindrical shape), but there are exceptions (a square / a square shape, an oval / an oval shape).

Before you begin …
Ask students to explain what is meant by *components* and *assemblies* and the connection between the two. You could focus on cars as a familiar example. A *component* is an individual *part*, such as the wheel of a car. An *assembly* is a number of *components* that have been *put together/assembled*. For example, a car engine is an *assembly*, *assembled* from hundreds of *components* such as pistons, shafts, electronic components, etc.

Ask students to explain what is meant by *shapes* and *features*. You could hold up the course CD as an example to illustrate the terms. It's a circular *shape*. One of its *features* is a hole in the centre.

1 **Students complete the task in pairs. Alternatively, this discussion could be done before students open their books. Read out the rubric and ask students to work in pairs before reporting back to the group.**

2 a ▶3.1 **Students listen and summarise the project.**

Answer

The aim of the project is to formulate a policy that will state which plug and socket configurations their company recommends, and explain the technical reasons why they are recommended.

b **Students complete the task in pairs.**

Answers

The *profile of the pins* means the shape of the individual pins, for example a rectangular cross-section or a circular cross-section.
A *standard configuration* means a uniform arrangement, for example in a given country all plugs have a standard layout – they all exactly the same.

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c ▶3.2 **Students listen and match descriptions and pictures.**

Answers

a 6 b 4 c 1 d 5 e 2 f 3

Before you begin …

Look at the meaning of the following terms in relation to a mains electrical circuit.

live = the wire through which current flows into an appliance
neutral = the wire through which current flows out of the appliance
earth = the electrical connection between the circuit and the ground
live also means a circuit is energised, i.e. that current is flowing around the circuit.

d ▶3.2 **Students complete the phrases and listen again to check their answers.**

e ▶3.3 **Students listen and underline the stressed syllable.**

Answers

rectangle; rectangular; triangle; triangular; cylinder; cylindrical; line; linear

Extension activity: shapes (Resource sheet 3a)

Give out Resource sheet 3a – a consolidation activity for shapes and adjectives.

Answers

2 square; square
3 triangle; triangular
4 circle; circular
5 oval; oval
6 cylinder; cylindrical
7 cube; cuboid
8 line; linear

3 a ▶3.4 **Students listen and answer the question.**

Answer

Picture b

b ▶3.4 **Students complete the extracts and listen again to check their answers.**

Answers

2 ridges; grooves; recessed; flush with; set back
3 pins

c **Students complete the task in pairs.**

4 a ▶3.5 **Students listen and make notes.**

Answers

1 Advantages: The plug resists pullout forces. Nothing can touch the pins if the plug is partially pulled out.
Disadvantages: It's difficult to pull out.
2 Advantages: Children can't stick things in the socket.
Disadvantages: If the mechanism is too sensitive, it can be difficult to insert the plug.

b **Students complete the task in pairs.**

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Explaining and assessing manufacturing techniques

Language note

You will find the following vocabulary useful in this section.
drill, mill, saw, shear, flame-cut, grind, cast, hammer
guillotine, punch, hole-saw, (toothed) blade, abrasive wheel, cutting wheel, kerf

Before you begin …
Ask students to explain what is meant by *manufacturing* (= producing things in large numbers). You could look at related words, for example *manufacturer, factory* (British English) / *plant* (American English), *production line, mass produce, mass production.*

5 **Students complete the task in pairs.**

Language note

Often, the names of tools (nouns) are exactly the same as the verbs that describe their function, for example to *saw* with a saw, to *drill* with a drill, to *hammer* with a hammer. The concept of *verbing* (making verbs from nouns) is common in industry when describing the functions of highly specific tools and machines, for example *to diamond drill* (using a diamond drill), *to jackhammer* (using a jackhammer/ pneumatic breaker), *to crane* (lift using a crane). Sometimes, however, the nouns that describe tools and machines differ from the verb describing their actions, as the noun ends with *-er*, for example *to grind* with a grinder, *to power wash* with a power washer.

6 a ▶3.6 **Students listen and answer the questions.**

Answers

1 T
2 F – casting is a different discipline
3 F – it's a slang term
4 F – work involving abrasives is noisier
5 T
6 T

b **Students complete the extract.**

Answers

1 Sawing
2 Shearing
3 Drilling
4 Milling
5 Flame-cutting

c **Students complete the definitions.**

Answers

2 guillotine
3 kerf
4 toothed blade
5 abrasive wheel
6 hole-saw

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Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 6b in more detail.
hardness = a material's resistance to abrasion
toughness = a material's resistance to breaking when subjected to tension (stretching) or bending
thermal properties = a material's characteristics at different temperatures
thermal stability = a material's ability to behave consistently at different temperatures (important because cutting processes such as sawing and grinding generate heat, which can damage thermally sensitive materials)
electrical properties = a material's ability to conduct electricity and its behaviour when an electric current passes through it (important because some cutting processes use an electric arc, only suitable with materials that are effective electrical conductors – i.e. metals)
edge quality = the degree of smoothness of the edge of a material after it has been cut (important because some techniques produce smoother cuts than others)
production volume = the amount produced (usually by a factory) (important because some cutting techniques are relatively time-consuming, making them unsuitable for mass production)
cutting wheel = an abrasive or toothed wheel designed to cut materials (note that milling machines use toothed metal cutting wheels to progressively shave thin layers of metal from the surfaces of components producing *swarf* = metal shavings produced by milling machines)
grinding = using an abrasive wheel to grind away the surface, producing hot particles of molten metal due to heat from friction in the form of sparks
combustible = can be burned

Before you begin ...
Ask students to explain what is meant by *high-pressure waterjet cutting* (= cutting materials using extremely powerful jets of water) and *heat distortion* (= changes in the shape of a component, due to heating).

7 a **Students complete the task in pairs.**

Answers

secondary operations: additional machining, such as polishing
net-shaped parts: parts with accurately cut edges; often intricate shapes
heat-affected zone: the area modified by high temperatures (resulting from the heat of cutting)
mechanical stresses: physical forces such as shear forces when sawing or guillotining metal
narrow kerf: narrow thickness of material removed during cutting; especially easy to do with waterjet cutting
tightly nested: when several components are cut from the same piece of material the components can be placed close together, making better use of the material

b ▶3.7 **Students listen and match the phrases to the extract. Ask students to explain what is meant by *abrasive waterjet* (= adding an abrasive powder to the water to increase its cutting power). You could ask students to suggest what sort of material the powder might be. For example, garnet is a type of rock widely used in abrasive materials. Garnet paper is also called sandpaper in everyday English.**

Answers

1 net-shaped parts
2 heat-affected zone
3 mechanical stresses
4 narrow kerf

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c ▶3.7 **Students complete the extracts and listen again to check their answers.**

Answers

1 especially good when
2 useless when
3 not the best solution
4 ideal for

8 **Students complete the task in pairs.**

Suggested answers

Drilling with a bit is good for cutting blind holes. Drilling with a hole-saw is ideal for cutting timber.
Flame-cutting is perfect for cutting metals. It's useless for cutting ceramics.
Grinding is perfect for cutting wide kerfs. It's totally unsuitable if you don't want a heat-affected zone.
Guillotining is especially good for cutting thin materials. It's not particularly suitable for cutting thick materials.
Milling is especially good for cutting metals. It's totally unsuitable for cutting timber.
Punching is suitable for cutting through holes. It's useless for cutting blind holes.
Sawing is ideal for cutting straight edges. It's not so good if you need to cut curved edges.
Waterjet cutting is ideal if you need curved edges. It's not so good for cutting very thick materials.

Explaining jointing and fixing techniques

Language note

You will find the following vocabulary useful in this section.
bolt, screw, rivet, clip, weld, adhesive, bond, glue, join, connect, fix
… to / on / onto / together / each other

9 **Students complete the task in pairs. For ideas, they could look around the room and identify different joints used in the furniture, fittings and fixtures.**

10 **a** ▶3.8 **Students listen and answer the questions.**

Answers

1 To involve their suppliers more actively in design
2 Doing a lot of work for no return and covering costs
3 They want to work with fewer suppliers, so there would be more work.

b **Students complete the table.**

Answers

1 Mechanical fixings: screw, rivet, clip
2 Non-mechanical fixings: weld, adhesive

c **Students label the pictures.**

Answers

1 weld
2 bolt
3 adhesive
4 screw
5 rivet
6 clip

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Note

There are two main types of welding:

- *gas welding* – often using a mixture of oxygen gas and acetylene gas, commonly referred to as *oxy-acetylene* or *oxy-fuel* (this technique can also be used for cutting metal)
- *arc welding* – using an electrical supply to generate an electric arc, which generates a high temperature

d **Students match the connections and groups.**

Answers

1 joining; fixing
2 bolting; riveting
3 bonding; welding; gluing

Extension activity: more vocabulary

You could look at the similarities/differences between the nouns and verbs used to describe joints. Elicit the verbs from the nouns, or vice versa, checking for the following four common mistakes.

Noun	Verb
a bolt	to bolt
a screw	to screw
a ~~connect~~ connection	to connect
a rivet	to rivet
a clip	to clip
a bond	to bond
some glue	to glue
some adhesive	to ~~adhesive~~ adhere
a weld	to weld
a ~~fix~~ fixing	to fix
a ~~join~~ joint	to join

11 **a** **Students complete the questions.**

Answers

1 together
2 each other
3 on
4 to/onto

b **Students complete the extract.**

Answers

1 on
2 each other
3 together
4 onto/to
5 to

c **Students answer the questions in pairs.**

Answers

1 Main advantage: They can be removed easily.
Main disadvantage: They can work loose.
2 It can't be removed easily.
3 Fixings can be inadequately tightened. Adhesives can be used on improperly prepared surfaces. Welds can be flawed.

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Extension activity: more vocabulary

You could look at the meaning of some of the terms on the webpage in more detail.
disconnected = the opposite of *connected*, can describe a joint and also an electrical connection/supply
tightly = the opposite of *loosely*. If a bolt is *tight* it has been turned with a large amount of force
vibration = shaking at a high frequency
flawed welds = the presence of small, bubble-like air pockets inside the mass of welded metal reducing the strength of the weld. Where quality is critical, welds are sometimes x-rayed to check for flaws

12 a **Students complete the task in pairs.**

Suggested answers

1 In early aircraft, timber frames were joined together with adhesive / glued together, or screws / screwed together.
2 In jet aircraft, alloy body panels are joined together with rivets / riveted together.
3 In aircraft cabins, the seats are fixed to the floor with bolts / bolted to the floor.
4 In aircraft cockpits, the windshield is bonded to the fuselage with adhesive / glued to the fuselage.

b **Students complete the task in pairs.**

Describing positions of assembled components

Language note

You will find the following vocabulary useful in this section.
above, adjacent to, alongside, below, beneath, beside, inside, next to, outside, over, underneath, within
contain, insert, locate, position, project, situate, suspend

Before you begin …
Ask students to explain what is meant by *relative positions* (= positions of things *related to* / *in relation to* other things). You could focus on a chair as a familiar example. Ask students to explain the relative positions of the main components – *legs, seat, backrest, armrests*. For example, the legs are below the seat, the backrest is above the seat, the armrests are above the seat, at the sides.

13 a **Students complete the task in pairs. Alternatively, this discussion could be done before students open their books. Write *Larry Walters and the flying garden chair*, or *'Lawnchair Larry' Walters* (the latter term is generally used in media articles about Larry Walters) on the board. Ask students to guess what real event this headline could be about.**

b **Students match the questions and paragraphs.**

Answers

a 2 b 3 c 4 d 1

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c **Students answer the questions.**

Answers

a The balloons climbed faster than expected, then entered controlled airspace adjacent to an airport.
b A rope tangled with a power line, then Mr Walters was arrested.
c The modern equivalent, cluster ballooning, is not a mainstream sport, but is becoming more popular.
d A garden chair, helium-filled weather balloons and ropes

14 a **Students label the diagrams.**

Answers

a over
b below; beneath; underneath
c alongside; adjacent to; beside
d around
e outside
f inside; within

b **Students complete the sentences.**

Answers

1 above
2 around
3 in
4 within
5 beneath

c **Students complete the descriptions. Students could use the article for extra help as the words are there.**

Answers

2 inserted
3 situated
4 suspended
5 located
6 projecting
7 positioned

d **Students answer the question.**

Answers

located; situated

Extension activity: more vocabulary

You could look at the meaning of some of the words in the article in more detail.
cluster = group, situated close together
helium (He) = a gas less dense than air
In early airships, *hydrogen* (*H*) was used but it is highly flammable and explosive when mixed with large amounts of *air*. Helium has the advantage of being *inert* i.e. it does not burn or react with other substances and is therefore safer.
bumper / fender (American English) = a buffer protecting car bodywork at front or rear
makeshift = put together quickly or in an amateur way, often a temporary assembly
airgun = a gun that fires pellets propelled by compressed air
lift = upward force
controlled airspace = areas, mostly around airports, where pilots cannot fly unless they are being directed by air traffic controllers

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Before you begin …

Look at the meaning of the following terms.

paragliding = using a parachute to take off and fly, usually from a slope on a hill or mountain
harness = equipment that fastens securely around the waist and legs, used in sports such as climbing, parachuting and bungee jumping
ballast = material used to add weight, i.e. to counteract lift
ropes = lines which have a circular cross-section
straps = lines which have a flat cross-section
cable tie = plastic band used to fix cables together, usually with a toothed surface which is pulled through a sleeve – a mechanism in the sleeve allows the strap to travel only one way, so that the tie can be tightened, but cannot be loosened
tape = adhesive band

15 a **Students complete the task in pairs.**

Answers

See audioscript 3.9 on pages 88 and 89

b ▶3.9 **Students listen and summarise the issues.**

Answers

1 It's pretty time-consuming to assemble.
2 Cable ties are fastened around the bottoms of the balloons, to fix them to the ropes.
3 The balloons are attached to ropes of different lengths, which are attached in groups to straps, like the branches of a tree.
4 Water is carried in bags, as ballast. Taps on the bags are used to release water.
5 The balloons can be released one by one.
6 The balloons can't be released one by one.

c **Students complete the task in pairs.**

Suggested answers

The helium could be contained within a smaller number of larger balloons. The balloons could be made of stronger material than weather balloons, and could be permanently fastened to the ropes or straps. This would make the balloon cluster faster to put together and inflate. Two or three of the balloons could have valves, allowing helium to be released during the flight. This would also allow the balloons to be deflated after the flight, so that they could be reused.

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Background information and useful web links

Describing component shapes and features (pages 22 and 23)

The aim of this section is to deal with essential language for describing two-dimensional and three-dimensional components and assemblies. Discussions using this type of language are commonplace in technical occupations, both at design stage (working out how components of different shapes and sizes will fit together), and during production/assembly (resolving problems when components don't fit together exactly as designed).

Explaining and assessing manufacturing techniques (pages 24 and 25)

This section covers the terms used to describe different cutting and machining techniques. Although the specific context is metalworking, many of the terms apply to operations involving materials that are common in mechanical, civil and process/manufacturing engineering. Within the logic of the overall unit, this section focuses on the production of individual components.

UHP waterjet cutting
http://www.flowcorp.com/
http://fr.youtube.com/watch?v = ljV_DZhyK2U

Explaining jointing and fixing techniques (pages 26 and 27)

This section looks at ways of fixing components together to form assemblies, representing a logical extension of the previous section on forming and machining individual components.

Describing positions of assembled components (pages 28 and 29)

This section further extends the theme of assembled components by dealing with language for describing the positions of components, relative to one another. Students at this level should already know some of the words, such as *next to* and *inside*. However, these are covered, as they are useful for teaching new synonyms.

Cluster ballooning
http://www.clusterballoon.org/

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TEACHER'S NOTES

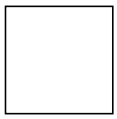
UNIT 3 Components and assemblies

Resource sheet 3a

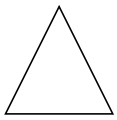
Describe the shapes.

1 This is a rectangle .
It's rectangular .

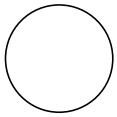
2 This is a _____ .
It's _____ .



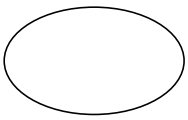
3 This is a _____ .
It's _____ .



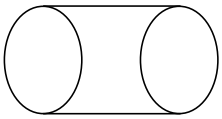
4 This is a _____ .
It's _____ .



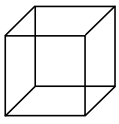
5 This is an _____ .
It's _____ .



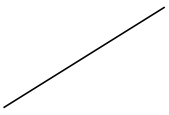
6 This is a _____ .
It's _____ .



7 This is a _____ .
It's _____ .



8 This is a _____ .
It's _____ .



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UNIT 4 Engineering design

- Working with drawings
- Discussing dimensions and precision
- Describing design phases and procedures
- Resolving design problems

Go to page 52 for essential background information and useful web links.

Working with drawings

Language note

You will find the following vocabulary useful in this section.
drawing, cross-section / section, elevation, exploded view, note, plan, schematic, specification
dimension, scale, to scale (drawn to a scale), scale off (measure from), full-scale, (one) to (five)

Before you begin …
Ask students to explain what is meant by *design* (= the collective word for all the information that's given in order to produce or build something) and *drawing* (= a type of picture that has been drawn in order to present design information). In engineering, most *designs* consist of *a set of* several *drawings*. You could discuss the fact that in general English, *design* is also used in an artistic sense, for example fashion design and interior design. In engineering, the term has a technical meaning, for example *design engineer, design calculations, design team, design phase, design fault*.

1 **Students complete the task in pairs.**

Answers

For the design of a large cruise ship, several hundred drawings would need to be produced. These would include general arrangement drawings, such as plans of the overall layout of each deck, elevations of the sides of the ship, and cross-sections through the ship at different points. Notes on these general arrangement drawings would then refer to more detailed drawings of assembly details. As well as being divided into small-scale general arrangement drawings and larger-scale details, the drawings would also be organised into different specialisations, such as structure, electrical power circuits, lighting circuits, water supply, air-conditioning, lifts, fire sprinkler systems, engine installations, etc.

2 a ▶4.1 **Students listen and answer the questions.**

Answers

1 Part of a staircase (Staircase 3, Deck C)
2 The number of panels, and their size

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b **Students complete the definitions.**

Answers

2 elevation
3 exploded view
4 cross-section
5 schematic
6 note
7 specification

c **Students complete the table.**

Answers

general arrangement: plan, elevation
detail: exploded view, cross-section

Language note

general arrangement drawing = shows the layout of a whole assembly or structure, but does not give details of smaller individual components
detail drawing = shows one or more smaller components in detail
Usually, *general arrangement* drawings have *notes* on them which give *references* to related *detail* drawings. For every *general arrangement* drawing, there are usually several related *detail* drawings.

d **Students answer the questions.**

Answers

1 elevation
2 cross-section
3 plan
4 schematic
5 exploded view

3 a **Students complete the task in pairs.**

Answers

The scale is the ratio between the size of items shown on a drawing, and their actual size (in reality). A scale rule has several scales, allowing dimensions to be measured on a drawing, to determine the actual size.

b ▶4.2 **Students listen and answer the questions.**

Answers

1 The width of the panel at the top
2 That you shouldn't scale off drawings. It's mentioned because Pavel suggests measuring the dimension on the drawings with a scale rule to find out the actual dimensions

Note

The golden rule in engineering is not to scale off drawings. Although drawings should be drawn to scale, there may have been inaccuracies in the drawing or printing process, which could lead to inaccurate dimensions being measured, especially in situations where dimensions need to be very precise. Generally, only dimensions that have been specified in writing on the drawing should be used. If dimensions are not specified, it is normal practice to request the information from the engineer who produced the drawing.

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C Students complete the extracts.

Answers

1 *Is this drawing to scale?* = Do the dimensions correspond with a scale?
2 *It's one to five.* = The dimensions on the drawing are one fifth of their real size.
3 … *you shouldn't scale off drawings* … = You shouldn't measure dimensions on a drawing using a scale rule and take them to be exact.
4 … *it's actual size, on a full-scale drawing* … = The dimensions on the drawing are the same as their real size.

4 Students complete the task in pairs.

Answers

Types of drawing required: a plan showing the perimeter of the handrail (possible scale 1:100); an elevation of a short length of the handrail (possible scale 1:10); a section of the handrail (possible scale 1:10); details showing key connections, such as those between handrail posts and deck, and top rail and posts (possible scale – actual size). Specification: type of steel, types of welded joint, types of bolt, type and colour of paint/coating, other materials such as plastic surround to top rail

Extension activity: measurements and measuring systems

Ask students what *millimetre* is used to measure = a unit for dimensions, in *metric*. Ask students to give some examples of other metric units commonly used to give dimensions in engineering and to relate their values, for example:
10 millimetres = 1 *centimetre*
1,000 millimetres = 1 *metre*
Ask students which of the dimensions are used most often in engineering. Millimetres are generally used as they are the most precise and practical unit. Centimetres are not usually used in engineering, and metres are only used for very large dimensions in civil engineering. For example, 65 cm would normally be expressed as 650 mm, and 4.8 metres as 4 800 mm.
Ask students if they know any other system for measuring, apart from the metric one. Do they know the missing words?
25.4 millimetres = 1 _____ (*inch*)
12 inches = 1 _____ (*foot*)
3 feet = 1 _____ (*yard*)
The other system is *imperial* which is used mainly in the United States. Although the UK uses imperial units on road traffic signs and in many everyday contexts, British industry uses metric units. International aviation and shipping still uses imperial, for example in aviation altitude is always expressed in feet and horizontal distances in nautical miles. Smaller fractions of inches can be expressed as $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ and $\frac{1}{1,000}$ of an inch.

5 Students complete the task in pairs. You could give out Resource sheet 4a for extra help.

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Discussing dimensions and precision

Language note

You will find the following vocabulary useful in this section.
accuracy, accurate, inaccurate, precision, precise, imprecise
tolerance, within tolerance, outside tolerance, plus or minus, to within, tight tolerance
length, width, height, thickness, depth, long/short, wide/narrow, high/low, thick/thin, deep/shallow
diameter, radius
Some of the words for describing dimensions are familiar to students at this level, for example *long, short*. These terms are included to highlight the link between adjectives and nouns, for example *long, length*, and opposites, for example *deep*, *shallow*.

6 a **Students complete the task in pairs.**

Answers

The words mean how exact something is, for example how closely the sizes of manufactured items match their designed size.

Extension activity: more vocabulary

Elicit words related to *precision* and *accuracy*. Students should try to come up with the words themselves and then check their answers by scanning the web page about superflat floors to find the words (*precise, imprecise, accurate, inaccurate*).

Noun	Adjective	Opposite adjective
Precision	_____	_____
Accuracy	_____	_____

b **Students read the article and answer the questions.**

Answers

1 A superflat floor has a much flatter surface. It's finished more precisely than an ordinary concrete floor.
2 Ordinary slabs can be flat to ±5mm. Superflat slabs can be flat to within 1mm.
3 Slight variations in floor level can cause forklifts to tilt, causing the forks to hit racks or drop items.

c **Students complete the task in pairs.**

Answers

Tolerance is the acceptable difference between ideal designed size and actual size. In machining and assembly processes, it is impossible to achieve entirely precise sizes. A degree of tolerance is always required.

d **Students complete the expressions.**

Answers

1 within
2 plus; minus
3 tight
4 outside

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Note

A *tight tolerance* can also be referred to as a *close tolerance*. The opposite of a *tight tolerance* is a *loose tolerance*. *Tight* and *loose tolerances* are relative, depending on the situation. For example, in concreting, ± 1 mm would be considered a *tight tolerance* (extremely accurate and difficult to achieve, given the material), whereas in many metalworking applications, ± 1 mm would be considered a *loose tolerance*, as metal can be machined to within a few hundredths of a millimetre.

e **Students complete the sentences.**

Answers

1 outside tolerance
2 ± 0.5 mm
3 within tolerance
4 tight tolerance

f **Students complete the task in pairs.**

Answers

Difference in meaning: Plus or minus 1mm means the size may vary by a maximum of 1 mm either side of the 'ideal' dimension. As an example, if the diameter of a steel bar is specified as 100 mm ± 1 mm, the diameter may be a maximum of 101 mm at its widest point and 99 mm at its narrowest point. Since the total variation can be 1 mm either side of the 100 mm 'ideal' (between 99 mm and 101 mm), the maximum total variation between the widest and narrowest points is 2 mm. However, no point must be further than 1 mm either side of the 'ideal' size.

Within 1 mm describes only the total variation in size. This means the size may vary by a maximum of 1mm above the ideal dimension (as long as no point is below the ideal dimension) or it may vary by a maximum of 1mm below the ideal dimension (as long as no point is above the ideal dimension). Therefore, a minimum diameter of 100 and a maximum of 101 would be within 1 mm, as would a minimum of 99 and a maximum of 100, and a minimum of 99.5 and a maximum of 100.5.

Examples of uses: It is usual to specify ± tolerances where a specific ideal size is critical, for example the size of a hole for a bolt. In this case, if the hole is too narrow (too far below the ideal size) the bolt will not fit into it. If the hole is too wide (too far above the ideal size), the bolt will not fit tightly enough. 'Within' is often used when specifying tolerances for concrete floor surfaces. In this case, the important issue is the total amount of variation between the highest and lowest points on the surface of the floor (which determines how smooth the floor is).

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 6b in more detail.
slab = the block of concrete that makes up a floor. It can be laid on the ground or supported by beams and columns to form the higher storeys of a building – structural engineers refer to this type as a *suspended slab*
warehouse = a building used for storing large quantities of goods
Automated Guided Vehicles = driverless vehicles which operate in warehouses and factories
high bay warehouse = tall warehouse, approx. 30 metres high, with multiple levels of racks for storing pallets
amplified = made greater

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7 a ▶4.3 **Students listen and answer the questions.**

Answers

1 A superflat finish for the entire floor
2 Free movement floors are superflat everywhere. On defined movement floors, only specific lanes are superflat.
3 Long, narrow lanes allow a higher-quality finish to be achieved.
4 This can be done at a later stage to make other parts of the floor superflat.
5 It can be positioned deeper in the concrete.

b Students complete the table. You could also introduce *breadth* and *broad* and ask students which two words in the table have the same meaning (*width* and *wide*).

Answers

1 long
2 wide
3 height
4 thick
5 depth

c Students complete the extract.

Answers

2 width
3 length
4 depth
5 thickness
6 height

d Students answer the questions.

Answers

diameter: the maximum width of a circle
radius: the distance from the centre of a circle to its circumference (half the diameter)

Extension activity: circles (Resource sheet 4b)

Give students Resource sheet 4b. Students label the diagram.

Answers

2 segment
3 cord
4 arc
5 diameter
6 tangent
7 segment
8 radius
9 circumference

8 Students complete the task in pairs.

Answers

The capital T refers to the thickness of the flanges. The small t refers to the thickness of the web. The capital W refers to the width of the flanges. The small w refers to half the width of the column from the centre of the web to the edges of the flanges. The small r refers to the radius of the curve at the joint between the web and the flanges. The capital D refers to the total depth of the column, from the top of one flange to the bottom of the opposite flange. The small d refers to the depth of the web, measured between the ends of the curves at the joints, at the point where the curves are flush with the face of the web.

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Describing design phases and procedures

Language note

You will find the following vocabulary useful in this section.
design brief, preliminary drawing, working drawing, (rough) sketch
amend, amendment, approve, approval, circulate, comment on, issue, resolve, revise, revision, specify, supersede

9 **Students complete the task in pairs.**

Answers

A design process is the development of a design. A typical design starts with a design brief, which states the design objectives. Initial ideas are then put together as rough sketches. These are then developed into preliminary drawings, which are more detailed and are often drawn to scale. The preliminary drawings are then developed, incorporating comments from different members of the design team, consultants and the client. Once the design has been sufficiently developed, working drawings are produced. These are then used for manufacturing/assembly/construction. Frequently, working drawings are revised (changed) during this latter phase, in order to resolve technical problems encountered during manufacturing/assembly/construction.

10 **a** **Students read the extracts and answer the questions.**

Answers

1 design information (at different stages of the design process)
2 sketches, design brief, revised/amended drawing, superseded drawing, preliminary drawing, working drawing, summary/notes

b **Students complete the task.**

Answers

1 b 2 d 3 c 4 a 5 e

c **Students complete the definitions.**

Answers

1 sketch
2 design brief
3 working drawing
4 preliminary drawing

d **Students find the words in Exercise 10c to match the definitions.**

Answers

2 revise
3 rough
4 issue
5 comment on
6 supersede
7 specify
8 resolve

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e **Students complete the task in pairs.**

Suggested answers

1 The drawing needs to be amended/revised.
2 The design needs to be sent to the client for comments and approval.
3 The site engineer needs to be contacted to check which revision of the drawing they have.
4 The three different contractors need to be issued with the revision.
5 Rough sketches need to be done first and the client to comment on them.

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 10a in more detail.
set of = collection/group
I attach / *Please find attached* / *Attached are/is* = commonly used phrases in emails, when sending attachments
hard copy = printed paper copy
contractor = a company that has been employed for a project/contract
fabrication = making something / putting something together
kick-off meeting = a meeting to get started
queries = questions
submitted = sent officially
Please note that = commonly used phrase in correspondence and refers to some important information

11 **a** **Students complete the task in pairs.**

b ▶4.4 **Students listen and match the extracts and the agenda items.**

Answers

1 b 2 a 3 c

c ▶4.4 **Students listen again and complete the task in pairs.**

d ▶4.5 **Students listen and answer the questions.**

Answers

1 The senior engineer will decide whether or not the team needs further revisions of a drawing.
2 If the drawing is needed, the team will receive copies of all further revisions. If not, no further revisions will be issued to the team.
3 S/he will liaise between the mechanical and electrical teams, and will report to the project manager.
4 All three design teams will be located in a single open-plan office.

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e **Students complete the task in pairs.**

Suggested answers

1 First, the preliminary drawing will be circulated to all the senior engineers. The engineers will decide whether or not the drawing is required by their team. If not, they will say it isn't required and after that, no more revisions of the drawing will be issued to them. If the drawing is required, they'll say it's needed. They might comment on the drawing and request amendments or approve it. They will also receive all further revisions of the drawing, including working drawings.
2 The mechanical and electrical teams will be able to work on the preliminary design together easily, thanks to the open-plan office. As the drawings are developed they'll be able to discuss amendments in the same way.
3 The mechanical and structural teams will be able to work together to solve the problem in the open-plan office and revised drawings will be produced. These will then be approved by both the mechanical and structural teams. Revised drawings will be issued and circulated to all those who need them.

Resolving design problems

Language note

You will find the following vocabulary useful in this section.
advise, clarify, confirm, disregard, indicate, propose, request, state, work to alternative, as per, clash, conflict, contradict, discrepancy

Before you begin …
Ask students to explain what is meant by *resolving* using synonyms such as *solving*, *sorting out*, *overcoming*, *finding solutions to*.

12 **Students complete the task in pairs.**

Answers

Often conflicting (different) information is shown on different drawings.
On one drawing, the dimensions of a component may not correspond with those shown on a related drawing. Clashes are another common problem – different drawings may show different components in the same position within an assembly, meaning the assembly will not fit together as designed. Key dimensions and assembly details may also be missing from the set of drawings, leaving the production with inadequate information.

13 **a** **Students read the extracts and answer the questions.**

Answers

1 Design problems and solutions
2 A query is a question. An instruction is an explanation of what to do / official permission to do something.
3 Written follow-up is important in order to keep a record for contractual/ financial purposes.

b **Students complete the task.**

Answers

2 869
3 869; 870
4 867; 868
5 867; 868; 869

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c **Students complete the sentences.**

Answers

1 clash
2 request
3 propose
4 advise
5 clarify

Extension activity: queries and instructions (Resource sheet 4c)

Give students Resource sheet 4c. Students complete the task in pairs with their books closed, as the text is the queries and instructions from page 36 of the Student's Book with certain words and phrases changed. Students could then check their answers against the texts on page 36.

Answers

2 discrepancy
3 conflicting
4 clarify
5 confirm
6 disregard
7 clash
8 proposed
9 as per
10 advise on
11 work to
12 contradicts
13 states
14 propose
15 provide
16 Further to
17 specified
18 intention
19 approved

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 13a in more detail.
cable tray = narrow metal deck suspended from a ceiling or fixed to a wall which supports several cables
ductwork = collective term for *ducts/ducting* – large-section pipes with circular or square profiles for carrying air, or a protective cover for cables or hoses
Grid D14 = in the designs of large structures a grid is often superimposed on plan drawings to allow elements and installations to be located relative to the gridlines – usually, the vertical gridlines are labelled with numbers and the horizontal gridlines are labelled with letters
black bolts = a term used in civil engineering to describe ordinary bolts
High Strength Friction Grip (HSFG) bolts = bolts which compress steel plates together so tightly that the plates are held together purely by the friction generated between the surfaces of the plates. This means that an HSFG bolt is not subjected to shear force (a scissoring action)

14 **a** **Students complete the task in pairs.**

Answers

See audioscript 4.6 on page 89

b **Students complete the extract.**

c ▶4.6 **Students listen and check their answers to Exercise 14b. You could hand out Resource sheet 4c, a 3-D representation of the assembly shown in the drawings in Exercise 14a.**

Answers

2 clarify
3 contradicts
4 clash
5 propose
6 alternative
7 as per
8 confirm

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d **Students complete the task either in class or as a homework activity.**

Suggested answers

As discussed today, I confirm that the connection between the plate and T section on the ski lift should have six bolts, not eight as shown on the detail. The two bolts shown on the detail which would clash with the flange of the T section are not required.

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Background information

Working with drawings (pages 30 and 31)

Drawings is a collective term for technical drawings, comprising a wide range of different views of components and assemblies, for example cross-sections or exploded views, at different scales showing different levels of detail. In everyday English, technical drawings are often referred to generally as *plans*; in the language of engineering, however, *plan* refers to just one type of view (a view from above). In the past, engineering drawings were often called *blueprints*, in reference to the blue and white colours used in printing processes at the time. Although the term is still used figuratively in everyday English, it is generally not used in engineering. Most engineering designs are now produced by computer, using CAD (computer-aided design) software. But the term *drawing* is still used to refer to on-screen designs.

Drawings
http://en.wikipedia.org/wiki/Plan_view
http://en.wikipedia.org/wiki/Elevation_(view)
http://en.wikipedia.org/wiki/Cross_section_(geometry)
http://en.wikipedia.org/wiki/Exploded_view
http://en.wikipedia.org/wiki/Schematic

Discussing dimensions and precision (pages 32 and 33)

In this section, tolerance (permissible deviation from a specified ideal measurement or value) is dealt with in the context of linear dimensions. However, the concept of tolerance can be applied to most types of measurements and values in engineering. In electrical applications, the frequency of an alternating current may be allowed to vary within a specified tolerance, for example ± 0.2 Hertz, or in manufacturing, the temperature of a production process involving heating may be allowed to vary within a specified temperature range, for example ± 2.5 °C.

Describing design phases and procedures (pages 34 and 35)

This section focuses on the process of developing designs, and circulating the relevant drawings and information among members of design and production teams. In engineering, this process often requires a lot of communication – especially written correspondence. The latter is particularly prevalent on projects involving several companies, as it represents a chronological record of the flow of design information, which can be central to contractual issues (causes of delays, attribution of responsibility for design quality, etc.)

Resolving design problems (pages 36 and 37)

This section deals with the communication that takes place as designs are revised to address technical problems arising during production/construction. On many engineering projects, levels of complexity and time pressure mean that it is virtually impossible to get designs right first time. A particular problem arises when there are large numbers of drawings – for different structural, mechanical and electrical components in a building or a vehicle. This invariably results in clashes and contradicting information between different drawings. Consequently, there is an ongoing process of design revisions as a project progresses, with the production team bringing technical problems to the attention of the design team, and the design team amending the design to resolve the problems. This communication process can take place verbally, but is often backed up with formal correspondence, for record purposes.

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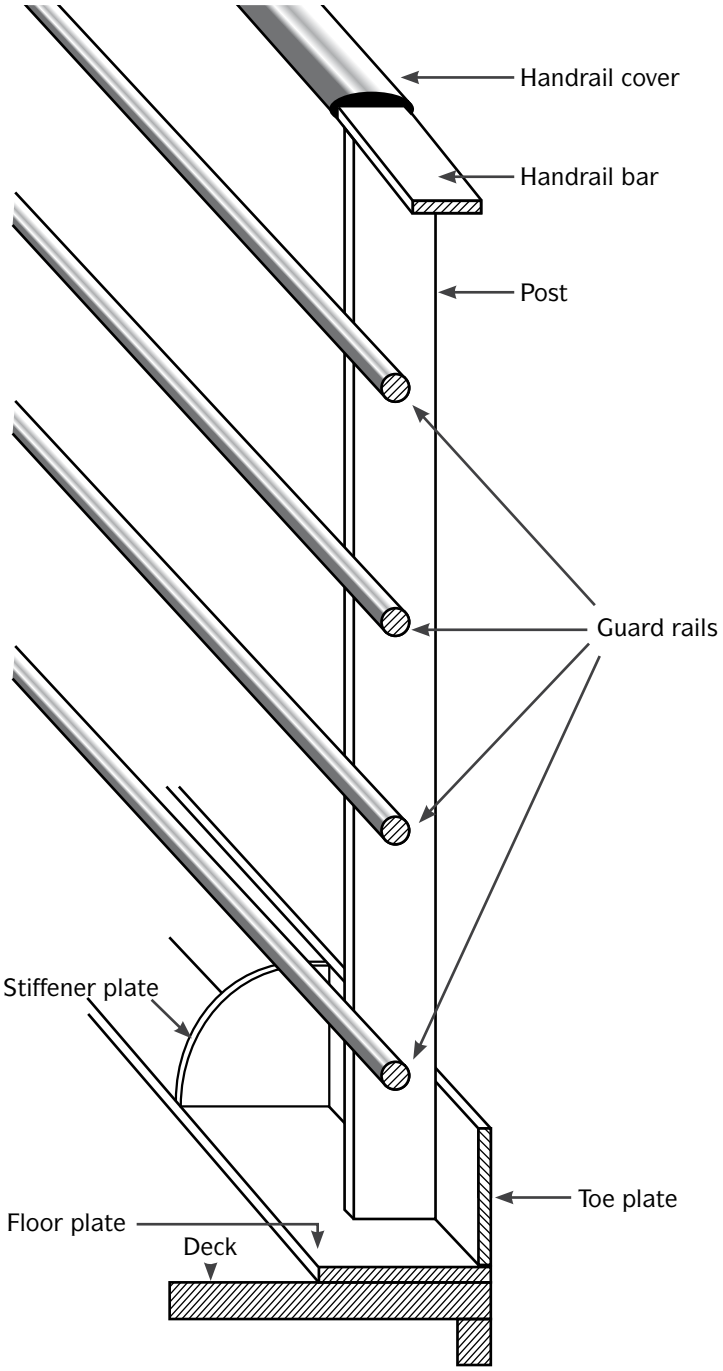
TEACHER'S NOTES

UNIT 4 Engineering design

Resource sheet 4a

You can use this drawing to help you with Exercise 5 on page 31.



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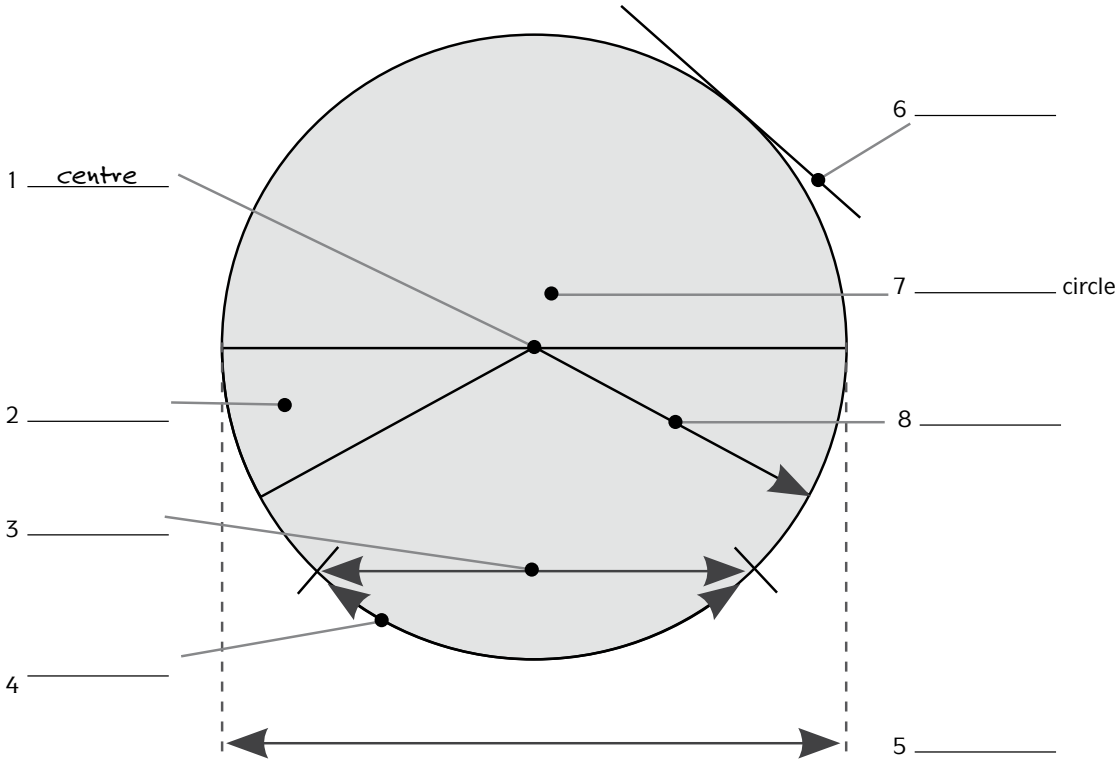
UNIT 4 Engineering design

Resource sheet 4b

Label the drawing using the words in the box.

arc ~~centre~~ circumference cord diameter radius segment (x2) tangent



9 Total distance around perimeter of circle = _____

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UNIT 4 Engineering design

Resource sheet 4c

Change the words and phrases in bold using the words and phrases in the boxes, in order to make the queries and instructions sound more professional.

clarify	confirm	conflicting	discrepancy	disregard	~~following~~

CONTRACTOR'S QUERY No. 867

(1) ~~**After**~~ Following our telephone conversation today, we note that there is a (2) **difference** between dwgs 76E and 78E, which indicate (3) **different** dimensions for the width of the roof opening. Please (4) **make it clear** which dimension is correct.

ENGINEER'S INSTRUCTION

We (5) **can tell you** the correct dimension is on dwg 76E. Please (6) **forget about** the dims on dwg 78E.

advise on	as per	clash	proposed	work to

CONTRACTOR'S QUERY No. 868

As discussed this morning on site, we confirm there is a (7) **collision** between the (8) **planned** cable tray (dwg E56) and air-conditioning ductwork (now installed (9) **like** dwg M118) in the ceiling void at Grid D14. Please (10) **tell us** an alternative cable route.

ENGINEER'S INSTRUCTION

Please (11) **do it like** attached sketch S33. Revision of dwg E56 to follow.

contradicts	propose	provide	states

CONTRACTOR'S QUERY No. 869

A note on dwg 11A specifies black bolts at the base of the ski lift cable support. This (12) **is different to** the specification, which (13) **says** that all joints to comprise High Strength Friction Grip Bolts. We (14) **are thinking about** using HSFG fixings at this location.

ENGINEER'S INSTRUCTION

Please (15) **give us** further details of the HSFG bolts you are proposing.

approved	further to	intention	specified

CONTRACTOR'S QUERY No. 870

(16) **After what was said in** query 869, the proposed HSFG bolts are as per those (17) **mentioned in the design** for all other bolted joints on the ski lift supports. Our (18) **hope** is to use a single bolt spec to facilitate assembly.

ENGINEER'S INSTRUCTION

(19) **We agree that's OK**.

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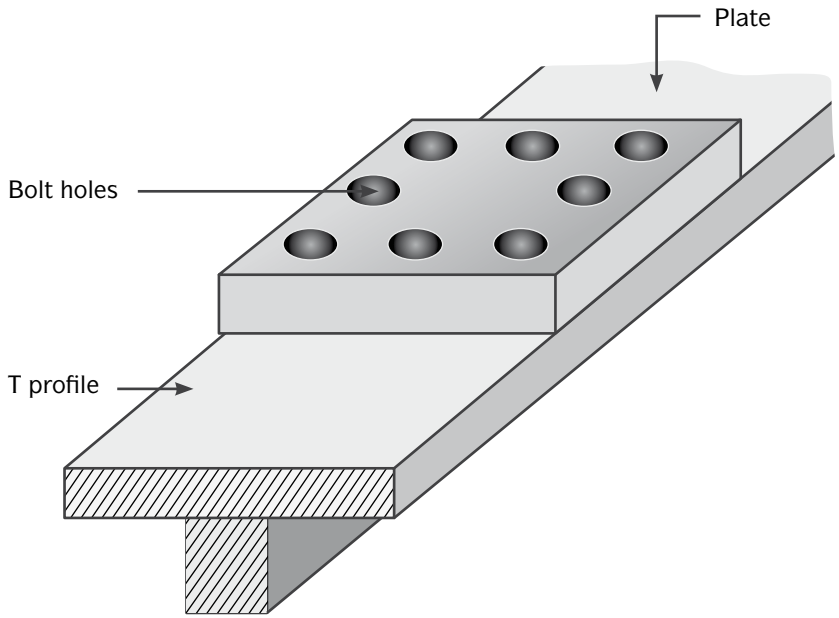
UNIT 4 Engineering design

Resource sheet 4d

You can use this drawing to help you with Exercise 14c on page 37.



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TEACHER'S NOTES

UNIT 5 Breaking point

- Describing types of technical problem
- Assessing and interpreting faults
- Describing the causes of faults
- Discussing repairs and maintenance

Go to page 67 for essential background information and useful web links.

Describing types of technical problem

Language note

You will find the following vocabulary useful in this section.
abrasion, heat, pressure, (physical) shock, vibration
bend, block, blow up, clog (up), crack, cut out, jam, leak, run out (of), snap, wear (out), work loose

Before you begin …
Ask students to give a brief description of a technical problem they recently experienced, either at work or at home. In larger groups, this could be done in pairs.

1 **Students complete the task in pairs.**

Answers
See audioscript 5.1 on page 89

Extension activity: Le Mans(Resource sheet 5a)

Give students Resource sheet 5a. Students read the text and mark the statements (T) or (F).

Answers
1 F 2 F 3 T 4 F 5 T 6 T

2 a ▶5.1 **Students listen and answer the questions.**

Answers
1 To finish first, first you must finish
2 Engineering enemies
3 Wear and tear

b ▶5.1 **Students complete the list and listen again to check their answers.**

Answers
1 heat
2 pressure
3 vibration
4 shocks
5 abrasion

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c **Students complete the task in pairs.**

Suggested answers

1 shocks
2 heat
3 abrasion
4 shocks
5 abrasion
6 abrasion
7 shocks
8 pressure (caused by heat)
9 vibration

Extension activity: automotive parts

If the focus on automotive parts is relevant or interesting to students, you could ask them to work in pairs and discuss how the parts listed in Exercise 2c would be different in a racing car compared with a road car.

Answers

1 chassis = much stiffer so that it doesn't twist due to high loads during cornering
2 engine = much more powerful, able to rev much higher
3 gearbox = has an electronically controlled semi-automatic gearbox controlled by paddles on the steering wheel, able to make much faster gear shifts and possibly seamless shifts where there is no interruption in power delivery during gear shifting
clutch = much stronger as required to cope with sudden power delivery
4 suspension = much stiffer to better cope with cornering forces and vertical load generated by downforce from wings
5 brakes = need to cope with much greater loads and operate at much higher temperatures
6 tyres = in dry conditions slick (smooth) tyres are used instead of grooved tyres, to maximise the contact patch – the amount of rubber in contact with the road surface
7 wings = specific to racing cars
8 cooling system = most racing cars do not have a fan to blow air over their radiators when the car is stationary, meaning they must be moving to benefit from the effects of air cooling; hence they may only remain standing for a very short time, to avoid overheating
9 nuts and bolts = stronger and lighter, with better resistance to working loose due to vibration

3 a ▶5.2 **Students listen and answer the questions.**

Answers

1 T
2 F – the driver switched the engine off
3 T
4 T
5 F – the wheel nut wouldn't turn
6 F – the driver didn't bend the suspension

b **Students complete the extracts.**

Answers

1 blocking
2 jam
3 bend; snap
4 crack

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c **Students complete the extracts.**

Answers

1 leaking out
2 run out
3 cut out
4 clog up
5 wearing out
6 blow up

d ▶5.2 **Students listen again and check their answers to Exercises 3b and 3c.**

Answers

See audioscript 5.2 on pages 89 and 90

e **Students complete the sentences.**

Answers

2 leaking out
3 jammed
4 clogged up
5 worked loose
6 blocked (up)
7 bent
8 worn out
9 run out

4 **Students complete the task in pairs.**

Answers

Monza has long straights and several chicanes. This means cars are at full-throttle for longer, and need to do a lot of heavy braking. Problems: engines can overheat and blow up; brakes can overheat; riding the kerbs can cause the suspension to crack, bend or snap; the right-hand corners cause the tyres on the left of the car to wear out faster than those on the right side; and leaves can block up the radiators.

Assessing and interpreting faults

Language note

You will find the following vocabulary useful in this section.
defect, defective, fault, faulty, intermittent(ly), major, minor, properly, sudden, systematic(ally), wear and tear
certainly (not), perhaps, possibly, probably (not)
I doubt it's …, It can't be …, It could be …, It might be …, It must be …, It sounds like it's …

Before you begin …
Ask students to explain what is meant by *assessing* (using synonyms such as *evaluating, examining, making judgements*) and *interpreting* (*understanding, reaching conclusions*).

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5 a **Students complete the task in pairs.**

Before you begin …
Ask students to explain what is meant by *troubleshooting* (= solving problems). Ask students to suggest the most effective ways of solving technical problems, generally speaking. For example, when you're trying to solve a technical fault whose cause you don't understand at first, what should you do in order to make progress? Elicit points such as *identifying possible causes, eliminating possibilities, using a process of elimination*.

b **Students complete the task in pairs.**

Answers

User's observations = what the person using the machine has noticed
Nature of fault = type of problem
Circumstances of fault = in what type of situation the fault happened/happens
External factors = things from outside, for example the weather or something hitting the machine
Process of elimination = thinking of possible problems and deciding which are *not* possible in order to reduce the number of possibilities
Identify the fault = find the fault / decide what the fault is
Determine action and urgency = decide what to do about the problem and decide how quickly it needs to be done

6 a ▶5.3 **Students listen and answer the questions.**

Answers

1 Check injection
2 Water in the fuel system
3 Because the fuel was put in directly from a delivery tanker
4 When the engine is started from cold
5 A faulty fuel pre-heater plug
6 The plug can be changed at the next service. It's not an urgent problem.

b **Students match the words and synonyms.**

Answers

1 defect
2 defective; faulty
3 major
4 minor
5 properly
6 intermittently
7 systematically

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Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 6a in more detail.
warning message = an electronic display which describes a problem by displaying a text message
fuel injection system = a device in an *internal combustion engine* (a petrol/gasoline or diesel engine) which injects *vaporised fuel* = an explosive mixture of fuel and air into the *piston cylinder* where it subsequently explodes, driving the piston downwards
sensor = a detecting/measuring device, for example a *heat sensor* or a *pressure sensor*
misfiring = when an engine is not running smoothly due to a fuel or ignition problem
refuel = fill up with fuel
tank = a *tank* is a static container for storing liquid outdoors or indoors or is part of a vehicle
tanker = a vehicle with a large tank on it which is used for transporting liquids in bulk
fuel pre-heater = a device in a diesel engine which heats up the fuel to be injected into the piston cylinder as the engine is started, allowing the vaporised fuel to explode more readily in the piston cylinder thus allowing the engine to start more quickly 'it's just one of the pre-heater plugs that's *gone*'
gone = a general term to describe components that have failed 'at the next service'
service = planned maintenance

Before you begin ...
Give students Resource sheet 5b. Students match the words and definitions.

Answers
1 c 2 g 3 h 4 a 5 i 6 d 7 f 8 e 9 b

c **Students complete the task in pairs.**

Answers
1 b 2 c 3 a

d **Students complete the task in pairs.**

Suggested answers
1 This is an intermittent problem. It's probably caused by wear and tear.
2 This was a sudden problem. It's probably a faulty part, or an installation problem.
3 This is a systematic problem. It's probably a faulty part, or an installation problem.

e **Students complete the table.**

Answers
2 It sounds like it's
3 It could be / It might be
4 I doubt it's
5 It can't be

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f ▶5.3 **Students complete the extracts and listen again to check their answers.**

Answers

2 it might be
3 it might be
4 it can't be
5 I doubt it's
6 It sounds like it's

Before you begin …
Look at the meaning of the following terms.

dump truck = a large off-road truck used for carrying heavy loads of earth, rocks or minerals
quarry = a large hole in the ground (an *opencast mine*) from which minerals are dug
down on power = has less power than it normally should
fuel consumption = the rate at which fuel is used

7 a **Students complete the task in pairs.**

Answers

minor; systematic

b **Students complete the task in pairs.**

Suggested answers

It can't be water in the fuel supply. (This would cause misfiring.)
It could be a clogged fuel filter. (The engine is performing consistently, but is down on power.)
I doubt it's a compression leak. (This would probably result in increased fuel consumption, and would probably cause more major problems.)
It can't be a lubrication problem. (This would cause overheating.)
I doubt it's a blockage in the exhaust system. (This would cause more major problems.)

Describing the causes of faults

Language note

You will find the following vocabulary useful in this section.
abnormal, disproportionate, imbalance, inadequate, incorrect, inoperable, insufficient, irregular, malfunction, undersized/oversized, undetected

8 **Students complete the task in pairs.**

Answers

checklists = lists of things to be checked
standard procedures = specific, planned ways of dealing with situations and problems
back-up installations = secondary/additional equipment that will work if main equipment fails
planned maintenance = replacing parts at planned times even if they are not worn out

Before you begin …
Look at the meaning of the following terms.

hydraulic pipe = high-pressure oil pipe, used to push pistons called hydraulic rams
fuel line = fuel pipe/hose
ruptured = broken/cracked
gliding = flying without power

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9 a **Students read the article and answer the questions. What could a pilot do in such a situation? Is it possible to control a large passenger aircraft when all engine power has been lost?**

Answers

1 An incorrect (oversized) hydraulic pipe was fitted to the right-hand engine.
2 The pipe rubbed against a fuel line.
3 The fuel line ruptured, resulting in a major leak.

b **Students complete the task.**

Answers

04:58 b 05:36 d 06:13 a 06:27 c

c **Students complete the task.**

Answers

2 oversized
3 inadequate
4 undetected
5 abnormal
6 insufficient
7 disproportionate
8 irregular
9 imbalance
10 malfunction
11 inoperable

d **Students complete the sentences.**

Answers

1 incorrect/abnormal
2 inadequate/insufficient
3 irregular
4 oversized
5 malfunction
6 imbalance
7 undetected
8 inoperable

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercises 9a and 9b in more detail.
flight data recorder = a digital device which records essential data on an aircraft (instrument readings etc.) which can be analysed by air accident investigators – often referred to as a *black box*
landing gear = the wheels of an aircraft
ram air turbine = propeller-like device which spins when placed in an airflow
fly-by-wire = flight controls operated electronically (connected by electrical wires) rather than by mechanically operated tension cables like those used to operate bicycle brakes
flaps = aerodynamic devices on the backs of aircraft wings used to increase the amount of lift generated by the wings in order to allow the aircraft to take off and land at reduced speed
spoilers = aerodynamic devices on the tops of wings, used to generate drag and downforce in order to slow the aircraft down during descent and just after landing – also called *air brakes*
cross-feed valve = valve allowing fuel to be fed from one tank to another

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10 a ▶5.4 **Students listen and answer the questions.**

Answers

1 F – the tyre pressures are well down
2 T
3 F – only one group of tyres is low
4 T

b Students complete the sentences.

Answers

1 abnormal/incorrect
2 insufficient/inadequate
3 disproportionate
4 proportionate

c Students complete the task in pairs.

Answers

In general, insufficient tyre pressures could be caused by: pressure loss over time (all tyres lose air pressure progressively over a period of several months) due to inadequate maintenance; a slow puncture (air leaking slowly from a small hole in the tyre); air leaking from a valve due to a problem with the valve, for example dirt in the valve preventing it from closing properly; a faulty pressure gauge on the compressor used to inflate the tyres, giving an incorrect pressure reading. With this specific problem, perhaps there was a fault with the compressor used to inflate that block of tyres – a different compressor to the one used to inflate the other blocks – and this gave the maintenance technician an incorrect pressure reading when inflating that block of tyres. It's unlikely that a technical problem with the tyres, such as slow punctures or leaking valves, would occur on several tyres at the same time and cause exactly the same loss in pressure across all the tyres.

Extension activity: technical problems

Ask students to think of a technical device or installation they are familiar with, and make a list of several technical problems that could occur with it. They should begin by describing the problems as symptoms, for example *it's overheating, it keeps cutting out*. They should then suggest possible causes of the symptoms described by their partners using phrases from Exercise 6e on page 41 (*It's possibly …, It's probably …, It might be …,* etc.) and adjectives from this section.

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Discussing repairs and maintenance

Language note

You will find the following vocabulary useful in this section.
adjust, disconnect, dismantle, drain, examine, reconnect, replace, service, tighten, top up

11 a **Students complete the task in pairs.**

Suggested answers

Repairs are done to correct technical problems after breakdowns have occurred.
Maintenance is done to prevent technical problems from occurring.

broken = repair, for example a bolt that has broken
clogged = repair, for example a filter that is completely clogged and has caused a technical problem; or maintenance, it is slightly clogged and is ready to be replaced
defective = repair, for example a part that was incorrectly manufactured and did not work
faulty = repair, for example a sensor that is giving incorrect measurements
worn = maintenance, for example worn tyres need to be replaced

b **Students complete the task in pairs.**

Suggested answers

Similarities: parts and fluids are replaced on a planned maintenance programme, parts are checked visually for wear and damage, and that they are tightly fixed, correctly aligned/balanced, etc.
Main difference: standards in aviation are more rigorous

12 a **Students match the contents and descriptions.**

Answers

2 d 3 c 4 a 5 g 6 b 7 j 8 e
9 h 10 i

b **Students match the verbs and definitions.**

Answers

2 d 3 j 4 g 5 c 6 b 7 i 8 a
9 h 10 e

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 12a in more detail.
access panel = bodywork part designed to be removed to allow technicians to reach internal parts
filter = material with small holes located in a flow of gas or liquid, used to block solid particles, for example to prevent them from damaging a sensitive mechanism such as a pump

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13 a ▶5.5 **Students listen and complete the notes.**

Answers

1 The level is OK.
2 The coolant is full of residue / black.
3 It looks reasonable.
4 OK, there are no signs of damage.
5 This will need to be looked at.

b ▶5.5 **Students listen again and answer the question.**

Answer

They're working on an industrial machine as their decision not to change the filter would be unacceptable in aircraft maintenance.

c Students complete the task in pairs.

Answers

Drain the coolant. Remove the filter, examine it and clean it. Put the filter back in. Replace the coolant. Adjust the blades and tighten them.

14 a Students read the email and summarise the problem.

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 14a in more detail.
external visual inspection = looking at the machine without dismantling anything
alignment = whether things are in line, parallel with each other
earthing = when electricity flows between a source of current and the ground
short circuit = when electricity flows directly between a live and neutral conductor, for example wires, resulting in a dangerously high electric current

b Students complete the task in pairs.

Answers

Isolate the electrical supply. Dismantle the external panels. Drain the lubricant. Check for internal damage. Remove damaged parts and replace them. Add lubricant. Adjust the blades. Put on the external panels. Reconnect the electrical supply. Test the machine.

15 Students complete the task in pairs.

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Background information and useful web links

Describing types of technical problem (pages 38 and 39)

Cars are used as the theme for this section on technical problems, as motor vehicles and the problems that can occur with them represent an area that should be familiar to students, from their general technical knowledge. The specific terms for car parts in Exercise 2c are covered in order to prepare students for the motor-racing context which is used to exemplify the main target language. It should be noted that the target language itself – verbs and adjectives used to describe technical problems – is relevant to all the main fields of engineering.

Lap of Monza
http://www.youtube.com/watch?v = VcUGC_GoVnc

Assessing and interpreting faults (pages 40 and 41)

Following the focus on describing technical problems in the last section, this section looks at assessing the nature and seriousness of faults. This reflects the typical communication process following a technical fault: contacting the relevant technical expert and explaining what the problem is, answering diagnostic questions to provide the expert with specific information about the fault, and obtaining an initial assessment from the expert on the nature and seriousness of the problem as well as advice on what action needs to be taken. The skills language covered in this section also reflects the uncertainty that often exists during technical troubleshooting (*It's possibly, It might be*, etc.) and the need to work through possible causes using a process of elimination.

Describing the causes of faults (pages 42 and 43)

This section deals primarily with adjectives commonly used for describing the causes of faults (*inadequate, incorrect,* etc.) At this point, you may also wish to focus on some of the language used for linking causes and effects, which is dealt with in Unit 9 on pages 76 and 77: *because of ..., cause ... to ..., consequently ..., due to ..., owing to ..., result in ..., as a result of ....*

Discussing repairs and maintenance (pages 44 and 45)

This section begins by contrasting the difference between repairs and maintenance. With many types of modern technology, maintenance programmes are carefully planned at design stage. This involves attributing *life-spans* to components (planning how long they are able to function effectively and safely), and thus prescribing when they need to be replaced. This is known as *preventive/preventative maintenance* – aiming to avoid breakdowns by replacing parts in time. Another trend as technology becomes more sophisticated is the tendency for devices and mechanisms to be built as *sealed units / non-serviceable parts* whose internal components cannot be repaired or replaced on site, requiring replacement of the complete unit, or requiring the unit to be sent back to the manufacturer. You could discuss some of these issues with students, from their points of view as designers/manufacturers, and/or as users.

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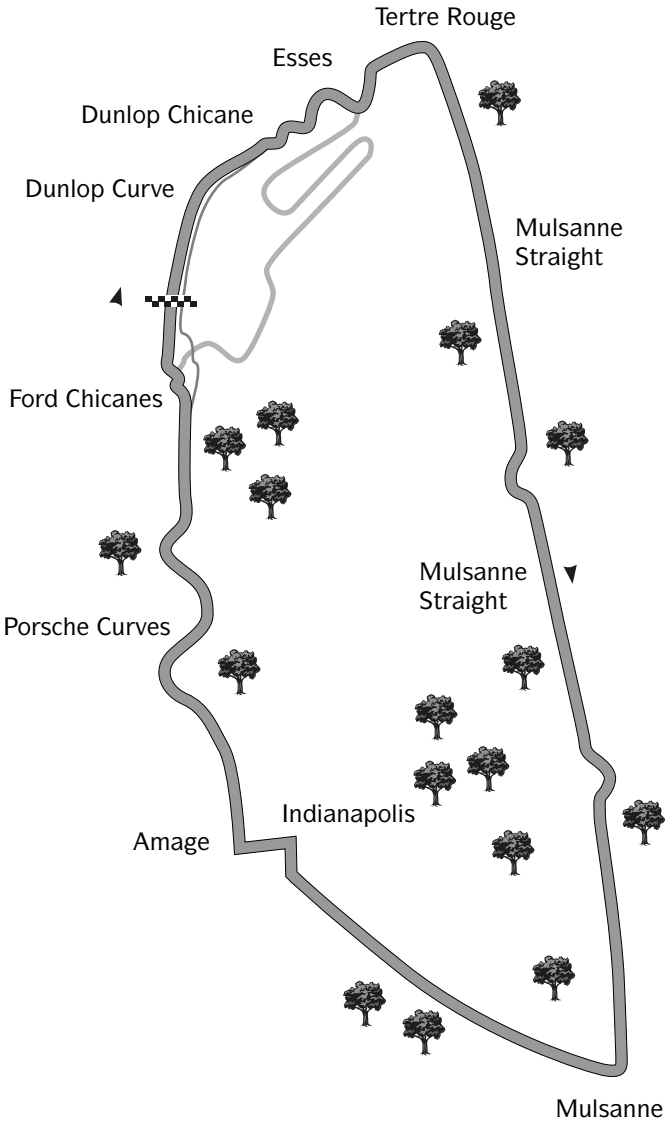
TEACHER'S NOTES

UNIT 5 Breaking point

Resource sheet 5a

Read the text about The Le Mans 24 Hours and mark the following statements True (T) or False (F).

1 The race is for off-road vehicles.
2 There's only one driver for each car.
3 The race use to be run on 'normal' roads.
4 Now the race doesn't use any public roads.
5 Bends were added to the Mulsanne Straight because it was too dangerous.
6 The cars that race in Le Mans have to be fast and very reliable.



The Le Mans 24 Hours is one of the world's most famous motor races. It is held each year in June near the city of Le Mans, in the west of France. The race is for sports cars, with several categories, ranging from slightly modified production cars, such as the Porsche 911, to specially built prototypes capable of speeds exceeding 300 km/h. Most cars are driven by a team of three drivers, who change over when the car comes into the pits for refuelling and new tyres.

The race was first run in 1923, on public roads. Later, a dedicated circuit was built. Since then, the 24-hour race has used this circuit, plus a section of the French national road network, which is closed to traffic during the event. The most famous section of road used for the race is a long straight called the Mulsanne Straight, which forms the fastest part of the track. Today, two chicanes are located along Mulsanne, requiring the cars to slow down in order to limit top speeds for safety reasons. The chicanes were introduced in 1990. In previous years, the fastest cars had been reaching almost 400 km/h along the tree-lined public road.

The key to Le Mans is reaching a compromise between speed and reliability. Designing and building a car capable of running at racing speed for 24 hours, non-stop (apart from short pit-stops), is a unique engineering challenge.

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UNIT 5 Breaking point

Resource sheet 5b

Match the words (1–9) and the definitions (a–h).

1 temp. gauge	a an electric motor used to turn over an internal combustion engine in order to start the engine
2 radiator	b a belt in a diesel engine which connects several pulleys in order to turn different engine devices in a synchronized manner – if this belt fails suddenly, fuel will be injected into the piston cylinders when the pistons are in the wrong positions, and the subsequent unsynchronized explosion can cause serious damage to the engine
3 electrical contact	c temperature gauge – a display which shows the temperature of the cooling water circulating in the engine
4 starter motor	d an automatic system which takes over in order to prevent a problem when a manual system is operated improperly, for example in antilock braking systems (ABS) on cars, if the driver brakes too hard, causing the wheels to lock, the ABS will automatically control the brakes through a software control system
5 manufacturing defect	e situated in front of the radiator, this is activated to blow air over the radiator and keep the water cool
6 override	f moves water around the engine block to cool it
7 water pump	g at the front of the vehicle, this dissipates the heat from the water into the air. When the vehicle is moving, air flows over it providing the required cooling effect - but when the vehicle is stationary and the engine is still running, for example in a traffic jam, as there is no airflow, there is a danger that the water will become too hot and boil.
8 fan	h physical connection between two electrical conductors, for example the connection between the end of a wire and a component
9 distribution belt	i a problem or fault with a component due to a problem when it was manufactured – not a problem that has occurred due to wear

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TEACHER'S NOTES

UNIT 6 Technical development

- Discussing technical requirements
- Suggesting ideas and solutions
- Assessing feasibility
- Describing improvements and redesigns

Go to page 78 for essential background information and useful web links.

Discussing technical requirements

Language note

You will find the following vocabulary useful in this section.
regarding, as regards, with regard to, in terms of, as far as ... is concerned
assess, determine, quantify, to what extent, the extent to which

Before you begin ...
Ask students to explain what is meant by *technical requirements* (= techincal needs and specifications).

1 **Students complete the task in pairs.**

Answers

Needs analysis (also called requirement analysis / gap analysis) is finding out what the requirements are for a new project by looking at all the factors that are involved and how they will interact
Budget = how much money is available, for example the budget for designing, building and testing a prototype for a new high-speed train
Capacity = how much something needs to produce or carry, for example how much power an electrical circuit must be able to carry
Dimensions = size, for example the diameter of the wheels of a mountain bike
Layout = the overall shape of something and the positions of different parts relative to one another, for example the layout of the main components of a car engine
Looks = what something looks like from an aesthetic point of view, for example the look of a car in terms of the shape of its bodywork
Performance = similar to capacity, for example how much power a generator needs to produce
Regulations = laws and standards that a design must comply with, for example safety regulations and quality standards
Timescale = how much time is available, for example the schedule for building a new airport

Before you begin ...
Ask students to explain what is meant by *simulator* (= a piece of equipment that is designed to represent real conditions). Ask students to give some examples of types of simulator, for example flight simulators used for pilot training or computer games which simulate race driving. You could discuss how the realism of simulators, notably the realism of the graphics, has improved over the years. Ask students for examples of simulators they've seen or tried which are especially realistic.

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2 a ▶6.1 **Students listen and make notes.**

Answers

1 capacity
2 graphics
3 timescale

b ▶6.1 **Students complete the phrases and then listen again to check their answers.**

Answers

1 regard
2 terms
3 concerned
4 as regards
5 regarding

c **Students write the questions.**

Answers

1 In terms of / As regards / With regard to / Concerning / Regarding the dimensions, what is the overall size of the module?
2 In terms of / As regards / With regard to / Concerning / Regarding the materials, what is the bodywork made of?
3 In terms of / As regards / With regard to / Concerning / Regarding the schedule, when will the work start?
4 In terms of / As regards / With regard to / Concerning / Regarding the power, what will the maximum output need to be?
5 In terms of / As regards / With regard to / Concerning / Regarding the heat resistance, what sort of temperature will the paint need to withstand?
6 In terms of / As regards / With regard to / Concerning / Regarding the tolerance, what level of precision do you want us to work to?

3 a ▶6.2 **Students listen and make notes.**

Answers

1 Can be varied considerably
2 Physical but not so extreme that people don't watch graphics
3 Best to try out effects in practice as it's difficult to do in theory

b ▶6.2 **Students complete the task in pairs.**

Answers

1 how much
2 the amount
3 calculate/give a quantity
4 judge/decide
5 measure/test

c **Students complete the extract.**

Answers

2 the degree to which
3 To what extent
4 to what extent / the degree to which
5 To what extent
6 quantify/determine
7 assess

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Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 3c in more detail.
dynamic = related to movement
dynamics = the study of the forces acting in moving mechanisms
statics = the study of structures and assemblies that remain still
engine thrust = pushing force generated by the engine
atmospheric turbulence = irregular air currents in the atmosphere
G-force = force of acceleration or deceleration acting on a body – 1G is equivalent to the acceleration generated by the force of gravity
magnitude = size
prototype = experimental device/vehicle built for the purposes of testing

4 **Students complete the task in pairs.**

Suggesting ideas and solutions

Language note

You will find the following vocabulary useful in this section.
what about ...? why don't we ...? why not ...? we could, couldn't we ...?
alternatively … another / the other possibility/option is to …

5 **Students complete the task in pairs.**

6 a **Students read the article and answer the questions.**

Answers

1 It's being carved from a block of sandstone.
2 He's overseeing the logistics of the project.
3 On a stone plinth
4 How to stop the slings from getting trapped beneath the statue, so they can be withdrawn, after the statue has been lowered onto the plinth by crane

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 6a in more detail.
logistics = handling and transporting
plinth = base
slings = flat straps which can be attached to crane hooks and placed under objects in order to lift them
low-loader = truck with a low, flat trailer, used for transporting large heavy vehicles, especially construction plant
stonemason = person who carves stone

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b **Students complete the task in pairs.**

Answers

drill = cut a hole
horizontal = level
bar = a long piece of metal with a circular section
vertical = at 90 degrees to the ground
lifting eyes = metal rings that hooks can be fixed to for lifting
resin = a type of strong adhesive
a grab = mechanical jaws that grip objects to lift them
friction = resistance to sliding when two surfaces are pressed together

c ▶6.3 **Students listen and answer the questions.**

Answers

1 Drill into the sides of the statue and insert horizontal bars, which could be used for lifting.
2 Drill into the top of the statue and insert vertical bars with lifting eyes, set into the stone with resin.
3 Use a grab on the end of the crane jib, to lift the statue by friction.

1 & 2 are rejected because holes can't be drilled into the statue (even if they were filled afterwards, they would be seen).
3 is rejected because the statue is too heavy and wide.

d **Students complete the suggestions.**

Answers

2 couldn't
3 could
4 alternatively
5 about
6 another
7 don't

e **Students complete the task in pairs.**

f **Students complete the task.**

Answers

The stonemasons' suggestion
Use blocks of ice. The blocks would act as temporary spacers between the statue and the plinth, to allow the slings to be withdrawn, and would then melt, allowing the statue to sit down on the plinth.
Potential problem 1: Outdoor temperatures below freezing would prevent the ice from melting. Solution: In this case, blowtorches or salt could be used to melt it.
Potential problem 2: Very hot weather would cause the ice to melt quickly.
Solution: To compensate for this, larger blocks of ice could simply be used.

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Extension activity: problem solving (Resource sheet 6a)

Give students Resource sheet 6a. Students try to come up with the most practical solution in pairs.

Answers

To dispose of the wet concrete, the U-bar can be inserted vertically into the top of the pile of wet concrete, with its legs in the concrete and its curved end at the top. The pile of concrete is then left to dry overnight. The following day, the excavating machine can pick up the dry pile with the U-bar set in it using chains and a hook, with the hook fastened to the top of the U-bar. To dispose of the block of dry concrete, two or three holes should be drilled into the block. These can then be filled with expanding cement. As the cement dries overnight, the force of the expansion will cause the block to crack and break into several smaller pieces. The smaller pieces can then be picked up using the excavator's bucket and put into the skip.

Assessing feasibility

Language note

You will find the following vocabulary useful in this section.
feasibility, feasible, budget, schedule
a tall order, cost an arm and a leg, cost peanuts, dead easy, there's no way, a painstaking job, perfectly feasible, stretching it, take forever and a day, it's borderline

8 a Students complete the task in pairs.

Answer

Feasibility means the *possibility of doing something.*

b Students complete the task in pairs.

9 a ▶6.4 Students listen and answer the questions.

Answers

1 For the bolts that will be used to fix the beams to the wall
2 Core drilled holes are formed after the concrete walls have been cast, using a diamond drill. Preformed holes are formed by putting plastic tubes into the walls while the concrete is being poured.
3 Space around the bolts, in the holes, to allow their position to be adjusted
4 Positioning the holes precisely or they won't match with the beams
5 Time and cost

b Students complete the task in pairs.

Answers

See audioscript 6.5 on page 91

c ▶6.5 Students listen and compare the points made with their answers in Exercise 9b.

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d ▶6.5 **Students listen again and answer the questions.**

Answers

1 The plastic tubes are cheap to buy and quick to put in.
2 It's slow.
3 Within 20 mm
4 Within 10 mm
5 That they're not positioned accurately
6 The tolerance

e **Students complete the expressions.**

Answers

2 peanuts ☺
3 painstaking ☺
4 perfectly ☺
5 stretching ☺
6 way ☹
7 borderline ☺
8 tall ☺
9 forever ☹
10 leg ☹

f **Students complete the task.**

g **Students complete the task in pairs.**

10 **Students complete the task in pairs.**

Suggested answers

1 A hammer-action drill would not be suitable for reinforced concrete, as there's no way it could drill through the steel reinforcing bars. Also, the diameter of the holes would be too great to drill using an ordinary drill bit. This is definitely not a feasible solution.
2 This could be a feasible solution. However, depending on the design of the ends of the beams, it might be difficult to get access to the holes after the beams were fitted. It'll be quite a painstaking job, as the beams might cover the holes, making it impossible to get cement into them.
3 This isn't really feasible, as the positions of the holes might be in unsuitable positions on the beams, for example very close to the edges of plates. This would not be acceptable in terms of structural strength. Also, drilling holes through steel beams on site would be very painstaking and time consuming compared with pre-drilling them during manufacturing.
4 This should be feasible from a structural point of view, but it'll cost an arm and a leg due to the need for additional steel columns. For that reason, it is not a feasible solution.

Describing improvements and redesigns

Language note

You will find the following vocabulary useful in this section.
redesign, refine, reinvent, remain, rethink, revamp
Achilles heel, design (something) from the ground up, (design it / start) from scratch, go back to the drawing board, make a quantum leap, reinvent the wheel, room for improvement

Before you begin …
Ask students to explain what is meant by *improvement* (= making things better) and *redesign* (= designing again in order to improve or change a design). What factors drive companies, and their employees, to improve products? What factors influence *how* products are improved?

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11 **Students complete the task in pairs.**

Suggested answers

Better-quality materials, for example making a tool from stainless steel instead of mild steel to prevent corrosion.
Lower unit cost, for example using a single-piece component instead of one that needs to be assembled from several parts, to make it faster to produce.
Make life easier for user, for example designing a simpler control panel that's quicker and easier to use, or maintenance-free components such as bearings that don't need lubricating regularly. Examples of other points that could be added: make products function more effectively, make them safer, make them last longer, make them more robust (stronger).

12 **a** **Students complete the task in pairs.**

Suggested answers

cables/connections: Improve the user interface by making cables easier to connect and disconnect; reduce environmental impact by making cables only from recyclable materials.
case: Improve aesthetics by offering a range of colours; make manufacturing easier by making the case from a smaller number of components.
ink/toner cartridges: Improve the user interface by making cartridges easier to remove and replace; consumables – make cartridges bigger so they last longer and need to be replaced less often.
paper: Improve reliability by refining mechanisms to help prevent paper blockages; improve output speed by making the paper flow faster.
power: Reduce environmental impact by having the printer switch off automatically when not in use.
software: Improve the user interface by making the software easier to use.

b ▶6.6 **Students listen and answer the question.**

Answer

Items 2 and 7

c ▶6.6 **Students listen again and answer the questions.**

Answers

1 No. The existing design has proved to be effective. The company doesn't have the resources to make fundamental changes to the production process.
2 Once
3 The software has been a major weakness of the existing model.
4 Significantly – it needs to be simpler to use

d **Students complete the task.**

Answers

2 invent again
3 improve the details
4 improve overall
5 think again
6 stay (the same)

e ▶6.6 **Students complete the task and then listen again to check their answers.**

Answers

2 ground up
3 room; improvement
4 Achilles heel
5 back; drawing board
6 quantum leap
7 scratch

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f **Students match the expressions and definitions.**

Answers

b 4 c 5 d 6 e 2; 7 f 3

g **Students complete the task.**

Answers

2 This is the product's Achilles heel.
3 There's no point reinventing the wheel.
4 We started from the ground up with this new design.
5 The new design is a quantum leap.
6 I think there's room for improvement.

13 **a** **Students complete the task in pairs.**

Answers

The first mechanical mouse was improved by refining its shape: by adding an additional button and a wheel to the top and by revamping the wheel mechanism under the mouse. The mechanism was redesigned to use a ball instead of wheels, although a wheel mechanism was still used inside the mouse; as the ball rolled, it caused the wheels to turn. For the optical mouse, the designers completely rethought the underside of the mouse. Instead of using a ball, they used optical sensors. They also redesigned the connection between the mouse and the computer, making it wireless instead of having a wire. For the touchpad, the designers went back to the drawing board and invented a new system using a sensitive surface.

b **Students complete the task in pairs.**

c **Students complete the task in pairs.**

Extension activity: improvements (Resource sheet 6b)

Ask students to think of a product or installation which could be redesigned and to answer the following questions in pairs. How significantly could it be improved? What aspects could be redesigned? What aspects do not require much improvement? You could give students Resource sheet 6b for extra help.

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Background information

Discussing technical requirements (pages 46 and 47)

This section focuses on needs analysis in technical contexts. This is an area of communication that frequently takes place between engineers and people from other professions, for example a marketing executive at a car manufacturer briefing design engineers on the performance requirements for a new car model, or an architect meeting a structural engineer to discuss the aesthetic requirements of a proposed building design.

Suggesting ideas and solutions (pages 48 and 49)

This section builds on the theme of needs analysis by looking at phrases for suggesting possible solutions for meeting needs / solving problems. This is an example of the creative side of engineering, and is reflected in the problem-solving activity that forms the basis of the section.

Assessing feasibility (pages 50 and 51)

Having so far covered discussing technical requirements, and suggesting possible solutions, the focus now moves to assessing the feasibility of proposed technical solutions.

Core drilling
http://www.youtube.com/watch?v = VHW89JC45mw

Describing improvements and redesigns (pages 52 and 53)

The focus of this section is on improving existing designs. In engineering, the aim of redesigning a device or installation can be both general (overall improvement) and specific, for example on a car, increasing fuel efficiency or adding more sophisticated automated safety systems. Frequently, the process of improvement and redesign requires engineers to work closely with other professions, such as marketing (integrating customer feedback).

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TEACHER'S NOTES

UNIT 6 Technical development

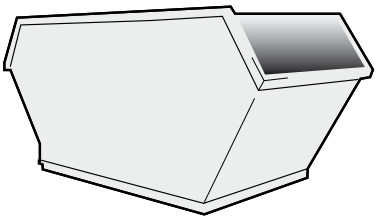
Resource sheet 6a

You are building your house yourself, and need to dispose of the following concrete waste into a skip within the next two or three days.

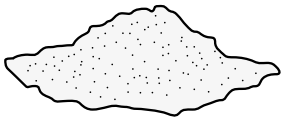
- a pile of wet concrete left over from a concrete floor you have just finished pouring
- a large block of solid concrete from the demolition of an old foundation

There are two problems: wet concrete mustn't be placed into the skip immediately as it will stick to the skip when it dries; the block of solid concrete is too big to be put into the skip in one piece.

With a partner, suggest the most practical, cost-effective way of disposing of the concrete. Note that you have the following shapes of steel bar and types of cement on the site. Some or all of these may be used as part of your solution. You may also use hand or power tools (sledge-hammer, disc saw, large drill, pneumatic breaker, etc.) and a small wheeled excavating machine which has a bucket and can lift reasonable weights using chains and a hook.



skip



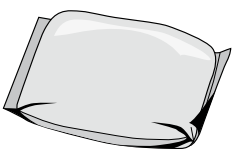
pile of wet concrete: 0.3 m³

large block of solid concrete: 2.5 m³

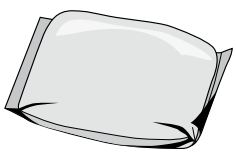
straight bar

L-bar

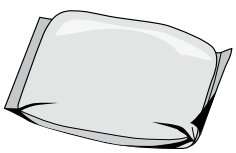
U-bar



bag of
ordinary cement



bag of
rapid-hardening cement
(dries and hardens quickly)



bag of
expanding cement
(expands when it dries)

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TEACHER'S NOTES

UNIT 6 Technical development

Resource sheet 6b

Suggestions for improvement

Think of a product or installation that could be redesigned. Answer the following questions and then complete the suggestions for improvement.

How significantly could it be improved?

What aspect could be redesigned?

What aspects do not require much improvement?

Name of product

_____

Overall, how significantly could the product be improved, in your opinion?

_____

_____

_____

Specific improvements

Aspects with potential for significant improvement	Aspects requiring minor improvement	Aspects not requiring improvement

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TEACHER'S NOTES

UNIT 7 Procedures and precautions

- Describing health and safety precautions
- Emphasising the importance of precautions
- Discussing regulations and standards
- Working with written instructions and notices

Go to page 91 for essential background information and useful web links.

Describing health and safety precautions

Language note

You will find the following vocabulary useful in this section.
confined space, corrosive, exposure (to a danger), (naked) flame, flammable, irritant, spark, toxic
ear protection, eye protection, gloves, mask

Before you begin …
Ask students to explain what is meant by *health and safety*. *Health* refers to *medical* issues, i.e. whether or not someone is *ill*/*sick*, whereas *safety* relates to avoiding *accidents*/*injuries*/*getting hurt*. Ask students to give some examples of *health* issues in industry, for example being exposed to toxic liquids or gases which can cause illness/sickness, and *safety* issues, for example wearing a hardhat as protection from falling objects.

1 **Students complete the task in pairs.**

Answers

Working with machines that have cutting wheels and blades; work at a high level where there's a risk of falling; work in excavations and tunnels where there is a risk of collapse or dangerous gases; lifting heavy objects with cranes where there is a risk of falling objects; processes that use high-pressure vessels and hoses/pipes where there is a risk of explosion; working with high-voltage electrical circuits where there is a risk of electrocution; processes that use flammable liquids and gases where there is a risk of fire or explosion.

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2 a **Students complete the task in pairs.**

Suggested answers

1 hazardous substances: dangerous materials, for example acid, asbestos; PPE: protective clothing and accessories, for example protective gloves, safety glasses
2 harmful: dangerous to health, for example chemicals that cause skin rashes; fumes: vapour or smoke, for example from liquid chemicals that evaporate at room temperature; asphyxiation hazards: danger of suffocation, for example due to concentrations of carbon dioxide / lack of oxygen
3 fire/explosion hazards: substances that could burn or explode if exposed to naked flames or sparks, for example petroleum products, butane/propane gas, alcohol
4 guards: protective shields around dangerous machine parts, for example the guards over the tops of circular saw blades
5 guardrails: rails at waist level to prevent people from falling, for example along the edges of high-level walkways and platforms; emergency exits: doors to allow rapid escape/evacuation, for example fire exits
6 electrical installations: situations involving contact with exposed electrical conductors such as electrical maintenance or work operations close to high-voltage cables
7 noise hazards: loud noise that can damage hearing, for example loud machines

b ▶7.1 **Students listen and match the extract to the agenda item.**

Answers

a 2 b 7 c 1 d 3

c ▶7.1 **Students listen to the recording again and match the words and definitions.**

Answers

2 e 3 b 4 g 5 f 6 a 7 h 8 c

Language note

flammable and *inflammable* have the same meaning.

d **Students complete the task. The first picture shows a *hardhat,* or *safety helmet*.**

Answers

ear protection, gloves, eye protection, mask

e **Students complete the task in pairs.**

Suggested answers

1 This is a confined space. You need to test the air using a CO_2 detector.
2 This is a corrosive substance. You need to wear gloves and eye protection, and a mask for protection from the fumes.
3 This makes sparks and is a noise hazard. You need to wear eye protection, ear protection and gloves.
4 This is a harmful substance. You need to wear gloves, and if there's a risk of splashing, eye protection.

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Extension activity: PPE (Resource sheet 7a)

Give students Resource sheet 7a. Students complete the table.

Answers

2 ear defenders
3 safety boots/shoes
4 welding mask
5 dust mask
6 respirator
7 safety harness
8 goggles
9 overalls
10 gauntlets

***Before you begin* …**
Ask students to explain what is meant by *silo* (= large tank-like container for storing granular materials or powder, for example a grain silo).

3 a Students complete the task in pairs.

Suggested answers

1 An analysis/prediction of the dangers involved in a working operation
2 A safe working procedure/method
3 Some maintenance work, which includes welding, is going to be carried out in the bottoms of some large grain silos (silo = storage tank for solid substances / powders)
4 Getting inside the silos
5 See audioscript 7.2 on page 91

b ▶7.2 Students listen and make notes.

Answers

1 Risk of someone falling; risk of gas bottles falling on someone
2 CO_2; fumes from metal; dust (explosion hazard)

c ▶7.2 Students listen again and answer the questions.

Answers

1 Access hazards: external staircase and internal ladder for safe access for workers, lower bottles into silo with a rope and make sure no workers are underneath in silo. Confined space hazards: use a CO_2 detector, use an air extractor.
2 An air extractor could blow dust into the air and make the problem worse.

***Before you begin* …**
Look at the meaning of the following terms.

petrol (American English = gasoline)

shot-blasting = firing small metal balls, propelled by compressed air, as an abrasive cleaning process

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4 **Students complete the task in pairs.**

Answers

One of the main dangers is from petrol fumes inside the tank, as there's a risk of explosion due to sparks and flames. The workers will have to be careful that there's no petrol inside the tank. The petrol will have to be drained and the inside will need to be washed out with water and detergent. The opening can then be flame-cut through the steel wall of the tank using an oxy-acetylene torch. PPE required for this job is eye protection (a welding mask), gloves and heavy overalls to protect the worker from molten metal. Alternatively, the cutting can be done with an angle-grinder. To be safe, the worker using the grinder will need to wear eye protection, ear protection, gloves and overalls. When welding the new pipe, the welder will need to wear eye protection (a welding mask), gloves and overalls. If arc welding is used and there are other people working nearby or passing by, screens should be placed around the welder to protect other people's eyes from flashes. When shot-blasting, the main dangers are to the eyes, and from noise and dust. Screens should be placed around the area and workers should wear eye protection, ear protection, dust masks, gloves and overalls. Before painting, it's important to read the safety documentation provided with the paint, as PPE may be required – for example, gloves, eye protection and possibly masks to protect workers from hazardous fumes. During all the operations, if any work is carried out more than two metres above the ground, scaffolding should be provided with handrails, as there is a risk of falling (workers should not stand on ladders while working). Also, all workers should wear hardhats.

Note

sand-blasting = this term is still used generically as sand was commonly used as an abrasive with compressed air. However, the dust given off by sand can cause the illness silicosis, and the technique is therefore problematic from a health and safety standpoint.

Extension activity: hazard analysis

Ask students to think of some maintenance, installation or construction work they have experience of. In pairs, they carry out a hazard analysis for the operation and come up with a safe system of work, including personal protective equipment.

Emphasising the importance of precautions

Language note

You will find the following vocabulary useful in this section.
at all times, under any/no circumstances, every single
it's crucial, it's essential, it's preferable, it's vital

Before you begin …
Ask students to explain what is meant by *emphasising precautions* and to think of some ways to do this in English.

5 a **Students complete the task in pairs.**

Answers

1 Maintenance work on low-voltage and high-voltage electrical equipment
2 Changing faulty or worn-out electrical parts, such as motors; repairing loose connects or damaged wires

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Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 5a in more detail.
switchboard = control panel containing several switches for all the individual circuits of an electrical installation
transformer = electrical device for modifying current and voltage
A *step-up transformer* increases voltage and reduces current (amps), a *step-down transformer* decreases voltage and increases current (amps). In factories and buildings that consume large amounts of electricity, the mains power supply often arrives at the site as a high-voltage supply, for example 10,000 volts. In order to be used by most electrical appliances, the high-voltage supply needs to be *stepped down* to a much lower voltage, for example 220 to 240 volts. Hence a *step-down transformer* is located at the point where the mains power cable arrives on the site.
exposed conductors = bare electrical wires or bars
isolating = switching off all or part of an electrical network so that current cannot flow through it
energising = switching on the power supply to an electrical network

b ▶7.3 **Students listen and answer the questions.**

Suggested answers

1 A place where a serious danger is present
2 A written form giving permission to work in a restricted area
3 The person responsible for electrical safety for the whole plant, and the only person authorised to issue permits to work
4 The procedure of having a single key to switchboards, ensuring only one person has access to switchgear at any given time

c ▶7.3 **Students complete the extracts and then listen again to check their answers.**

Answers

1 at all times
2 Under no circumstances should anyone
3 every single time
4 just a single
5 it's vital

d **Students complete the task.**

Answers

1 more
2 more
3 less
4 more

Pronunciation focus

Ask students to underline the stressed syllable in the following words and practise saying the words.

crucial essential preferable vital advisable

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e **Students rewrite the precautions.**

Answers

2 It's crucial/essential/vital to test the circuit is isolated.
3 The alarm should be reset every single time you start the system.
4 It's crucial/essential/vital to check that the cable is not damaged.
5 It's crucial/essential/vital that you should only store non-flammable materials in this zone.
6 Under no circumstances should anyone enter the restricted area without permission.
7 Before pressurising the system, every single connection must be tight.

f **Students complete the task in pairs.**

6 a **Students complete the task.**

Note

The system of using helicopters to work on live power lines is based on the principle that electrical current seeks to flow into the ground. If a person touches an exposed, live electrical wire while he or she is touching, or connected to, the ground in some way then electrocution will result from electrical current flowing through the person. However, if the person is not connected to the ground in any way, then no current can flow to the earth. This practice does have other electrocution risks. If the person touches two of the wires on the power line at the same time, a short circuit will result, and electrocution will occur. Touching a wire and any part of a pylon (which is connected to the ground) will have similar effects. Electrocution can also result from electrical arcs, as high-voltage power can jump gaps without the need for direct physical contact. The mass of the cradle and helicopter will also cause an electrical current to flow from the power line into the cradle and helicopter (albeit with a smaller current than would result from an earth connection). The latter phenomenon requires special precautions to be taken by live-line workers, who need to wear special suits containing metallic threads, which channel the electricity around the worker, based on an electrical principle known as a Faraday cage (if a body is suspended inside a metal cage that is electrified, no current will flow through the body).

c **Students complete the task in pairs.**

Suggested answers

1 It's essential that the crew obtain information on weather conditions. It's crucial that pilots are highly trained and experienced. It's vital that a tension release mechanism is in place.
2 Under no circumstances should operatives work on the line without wearing hot suits and eye protection. It's vital that the crew are highly trained.
3 The cables and platform must be checked every single time they are used. It's vital that twin-engine helicopters are used and these must be maintained to the highest standard at all times.

d ▶7.4 **Students listen and answer the questions.**

Answers

Before starting work, it's vital to isolate the circuit at the switchboard. Then, circuits should be systematically tested to be 100% sure that there's no current. During work, it's essential to tighten connections fully. And it's crucial to ensure that no insulation is damaged. To finish, all the wires should be checked – under no circumstances should there be any loose wires. Then the circuit should be systematically tested.

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Extension activity: live line precautions (Resource sheet 7b)

Give students Resource sheet 7b. Students complete the table.

Note

This activity requires knowledge of the basic principles of electricity.

Suggested answers

2 It's crucial/essential/vital not to hold on to two conductors at the same time. (See previous answer)
3 It's crucial/essential/vital not to connect yourself to a pylon using a strong, steel cable. This would result in the current earthing through you and the cable when you touched a conductor, causing electrocution.
4 There's no need to / You don't need to switch off the current running through the power line.
5 It's advisable/preferable to work during dry weather. Wet conditions increase the electrical conductivity of the air, increasing the risk of electricity arcing over longer distances.
6 It's advisable/preferable not to work during wet weather. (See previous answer)
7 It's crucial/essential/vital to wear a hot suit with metal threads in it. This conducts electricity around the body and into the cradle.
8 There's no need to / You don't need to wear a parachute. A parachute would be of little use at such a low altitude.
9 It's crucial/essential/vital not to anchor the cradle to the ground with a steel cable. This would result in the current earthing through the cable and anyone touching it.
10 There's no need to / You don't need to wear shoes with thick, rubber soles. The hot suit surrounds the feet, passing under the soles of the shoes. This would make the insulation provided by thick, rubber soles useless. The aim of the hot suit is to conduct electricity to the cradle floor, and thus to the mass of the cradle and helicopter.

7 **Students complete the task in pairs.**

Discussing regulations and standards

Language note

You will find the following vocabulary useful in this section.
adhere to, allow, authorise, banned, break the law, breach, compulsory, comply with, conform to, contravene, forbidden, illegal, law, legal obligation/requirement, legislation, obligatory, permitted, prohibited, regulation, stipulate

8 **Students complete the task in pairs.**

Answers

Regulations are laws; they are compulsory. For example, if companies breach (break) safety regulations, they can be fined (given financial penalties) and, in serious cases, managers who are responsible for breaches of regulations can be given prison sentences. Standards, such as quality and design standards, are sometimes compulsory, for example the design and manufacture of motorcycle helmets or car tyres. Sometimes, however, they are optional, for example ISO quality assurance.

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9 a **Students complete the task in pairs.**

Suggested answers

Risk of fire/explosion – no smoking, the provision of fire-fighting equipment and training. Danger of people falling from tall structures and into water – handrails required to give edge protection and life jackets need to be worn in certain situations. Risk of skin irritations from petroleum products – gloves and overalls required. Risk of air crashes as helicopters land and take off from platforms – special training required for pilots and special precautions needed for safe operation of helidecks.

b ▶7.5 **Students listen and answer the questions.**

Answers

1 Specific safety regulations
2 Compulsory personal protective equipment; prohibited activities, such as smoking
3 That the obligations are legal requirements

c ▶7.5 **Students complete the extracts and listen again to check their answers.**

Answers

2 compulsory
3 prohibited
4 requirements
5 stipulated
6 legislation
7 contravene
8 comply with

d **Students complete the groups of synonyms.**

Answers

2 permitted
3 comply with
4 stipulated
5 contravene
6 legislation; requirements; obligations
7 compulsory

10 a **Students complete the extract.**

Answers

2 stipulated
3 compulsory
4 legislation
5 comply with
6 requirements
7 obligations

Before you begin …
Look at the meaning of the following terms.

helideck = raised deck/platform on which helicopters land – a helicopter landing site on the ground is usually called a *helipad*
overhanging = projecting/extending beyond an edge
ground crew = personnel connected with aviation who work on the ground, for example at an airport
approach = phase of flight just before an aircraft lands, also often called *final approach*
perimeter protection = safety installation to stop people falling over an edge, for example a *guardrail/handrail*
anchor points = fixing points used to secure cables

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b **Students complete the task in pairs.**

Answers

1 to give the ground crew access to all parts of the helicopter
2 to avoid risk of collisions during take-off/landing
3 to avoid risk of collisions during take-off/landing
4 to tie down parked helicopters

11 **Students complete the task in pairs.**

Working with written instructions and notices

Language note

You will find the following vocabulary useful in this section.
BEWARE, CAUTION, DANGER, IMPORTANT, WARNING
Passive, full (instead of contracted) forms, omission of articles
when/before ...ing, in the event of (= if), as (= because), therefore (= so), may (= can/could)

12 **Students complete the task in pairs.**

Answers

1 Safety warnings, operating precautions for machines and maintenance instructions on machines
2 Effective notices and instructions are as short as possible, use clear language, and emphasise important points, for example dangers.

13 **a** **Students complete the task in pairs.**

Answers

a Could do both
b Could damage the machine
c Could injure workers
d Could damage the machine
e Could do both

b **Students answer the questions.**

Answers

1 danger
2 important

14 **a** **Students answer the questions in pairs.**

b ▶7.6 **Students listen and identify the differences.**

Answers

1 sp: active (*You should do it*)
wr: passive (*It should be done*)
2 sp: contractions (*shouldn't*, *it's*)
wr: word pairs written in full (*should not*, *it is*)
3 *if* (sp) = *in the event of* (wr); *because* (sp) = *as* (wr); *so* (sp) = *therefore* (wr); *can/could* (sp) = *may* (wr)

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Before you begin …
Look at the meaning of *blower* (= a device which pumps/blows air to generate a rapid airflow). It consists of rotors which spin inside an enclosed chamber – the chamber having an inlet and outlet. The rotors of a blower spin around an axis which is at 90 degrees to the airflow, unlike fans and propellers, which spin around an axis that is in line with the airflow.

15 a **Students complete the task in pairs.**

Suggested answers

*Objects **should not be placed** in front of the air inlet. The inlet grille **should be kept** free from obstructions, and **should be cleaned** regularly**. In the event of** damage to the inlet grille, the blower **must be stopped** immediately. Serious harm **may be caused** by foreign bodies entering the duct, **as** the unit contains precision-engineered parts revolving at speed, and is **therefore** highly susceptible to damage.*
***Before** start**ing** the blower, **it is** important to ensure that the external vents at the end of the air-intake duct are open. **When** open**ing** the vents, the adjusting handle **should be** fully **extended**. **When** clos**ing** the vents, the handle **should be turned** and **allowed** to return under the force of the spring. The handle **should not be pushed**, **as** this **may** strain the spring mechanism, and **therefore** result in damage.*

b **Students complete the task either in class or as a homework activity.**

c **Students complete the task in pairs.**

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Background information and useful web links

Describing health and safety precautions (pages 54 and 55)

The main themes of this section are basic safety equipment, *personal protective equipment* (PPE) related to common industrial hazards, and *hazard analysis* – a term used to describe safety planning, where a given industrial operation is thought through carefully in advance, from a safety standpoint, in order to identify the potential dangers so that a *safe system of work* can be put in place. In industry, increasing emphasis is placed on safety planning at all stages of the development process. This often requires engineers to design-in safety at conception stage, thinking about how the devices, installations and structures they design can be put together safely, at the stage when their *designs* are still on the drawing board.

Health and safety regulations for PPE
http://www.hse.gov.uk/pubns/indg174.pdf

Emphasising the importance of precautions (pages 56 and 57)

This section focuses on the skill of emphasising and stressing the importance of safety precautions. The context focuses on precautions for electrical maintenance, although clearly the target phrases can be applied to any branch of engineering.

EHV live line maintenance
http://fr.youtube.com/watch?v=Z3q9WdjD5wc

Helicopters in live-line work
http://www.eurocopter.com/site/docs_wsw/fichiers_communs/docs/pa-54-22-01.pdf

Discussing regulations and standards (pages 58 and 59)

Regulations and standards are relevant to engineering in various domains. Examples are quality standards, design standards and codes of practice, and safety regulations.

Working with written instructions and notices (pages 60 and 61)

This section explores the main differences in style between spoken English and written notices and instructions. This is relevant to engineers and technicians as people who frequently need to read and understand notices and written instructions, and also as people who often write notes and instructions in abbreviated form on drawings and in specifications.

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UNIT 7 Procedures and precautions

Resource sheet 7a

Complete the table below with the types of Personal Protective Equipment.

dust mask ~~ear plugs~~ ear defenders gauntlets goggles overalls respirator safety boots/shoes safety harness welding mask

Item of Personal Protective Equipment	Description
1 ear plugs	inserted in the ears to protect the hearing
2	protect the hearing by covering the ears – can also be attached to the sides of a hardhat
3	have steel toe caps and reinforced soles
4	has dark glass to protect the eyes from bright flashes of light
5	filters solid particles from the air
6	gas mask – filters gas particles from the air
7	prevents the wearer from falling
8	another general term for safety glasses
9	for covering the body, arms and legs
10	long gloves which extend up the arms

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UNIT 7 Procedures and precautions

Resource sheet 7b

Use the words in the box to write precautions that either should or don't need to be taken by line workers.

It's	advisable crucial essential preferable vital	to not to	...
There's no You don't	need to	...	

DOs and DON'Ts for line workers during high-voltage, live-line maintenance by helicopter:

1 ... touch only one conductor at a time.

It's crucial/essential/vital to touch only one conductor at a time. If you touched two conductors, it would result in a short circuit passing through you, causing electrocution.

2 ... hold on to two conductors at the same time.

3 ... connect yourself to a pylon using a strong, steel cable.

4 ... switch off the current running through the power line.

5 ... work during dry weather.

6 ... work during wet weather.

7 ... wear a hot suit with metal threads in it.

8 ... wear a parachute.

9 ... anchor the cradle to the ground with a steel cable.

10 ... wear shoes with thick, rubber soles.

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UNIT 8 Monitoring and control

- Describing automated systems
- Referring to measurable parameters
- Discussing readings and trends
- Giving approximate figures

Go to page 103 for essential background information and useful web links.

Describing automated systems

Language note

You will find the following vocabulary useful in this section.
activate, control, detect, detector, measurement, pick up (detect), reading, regulate, sense (detect), sensor, set off (activate), trigger (activate)

Before you begin …
Ask students to explain what is meant by *automated systems* and to give some examples. You could focus on automatic systems in cars, for example gears, anti-lock braking system (ABS), air-conditioning (automatically maintains a selected temperature), headlights (triggered by light sensors), windscreen wipers (which detect raindrops) etc.

1 **Students complete the task in pairs.**

Answers

An automated system can function autonomously, without human control.
A manual system requires human control. A Building Management System is a centralised computer system that monitors and controls a wide range of functions in a large building, such as the lights, heating, air-conditioning, smoke detectors, fire alarms, lifts and security systems.

Before you begin …
The *mechanical and electrical* systems within large modern buildings are referred to within the construction industry as M&E (see the rubric for Exercise 2a). Ask students to think about the types of system that this collective term refers to in buildings such as offices, hospitals, shopping malls and schools/colleges/universities. Note that M&E does not normally include waste pipes and drains.

Mechanical systems include:
air-conditioning
domestic cold water pipes (supply to taps/faucets)
domestic hot water pipes (supply to taps/faucets)
sprinkler systems (triggered in the event of a fire)
natural gas pipes (to boilers / water heaters)
medical gases (in hospitals)
oil pipes (to burners for heating)
automatic doors,
lifts/elevators
pumps (in basement drainage systems)

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Electrical systems include:
power sockets
lights
electric convector heaters
fire detection and alarm systems
intruder detection and alarm systems
telephone and data cables

2 a ▶8.1 **Students listen and answer the questions.**

Answers
1 It's a very green/environmentally orientated company.
2 Energy saving will be an important consideration in the design.
3 Sensors that detect the presence of people
4 He wants to present two different design options to the client. He describes option one as *a building with maximum automation*.

b ▶8.2 **Ask students what is meant by *sensors* and *controls*. Students listen to the recording and tick the points mentioned.**

Answers
1 ✓ 2 ✓ 3 ✗ 4 ✓

c Students match the words and synonyms.

Answers
2 reading
3 regulate
4 detect; pick up
5 set off; trigger

Pronunciation focus

Ask students to underline the stressed syllable in the following words and practise saying the words.

activate, control, detect, detector, measurement, regulate, sensor, trigger

d ▶8.2 **Students complete the extracts and then could listen again to check their answers.**

Answers
2 control
3 senses
4 reading
5 detects; triggers
6 set off
7 regulate

e Students complete the task in pairs.

Suggested answers
1 Presence detectors pick up movement and can activate light switches.
2 Smoke detectors sense smoke and trigger fire alarms.
3 Thermostats can regulate room temperature by controlling electric convector heaters.
4 Pressure plates can detect the weight of a person and set off intruder alarms.

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Extension activity: reading (Resource sheet 8a)

Give students Resource sheet 8a for further practice of the target vocabulary.

Answers

a

1	regulated	4	sensing	7	controlled
2	sensors	5	detected	8	setting off
3	detectors	6	triggered	9	picked up

b

1	The vault.	2	The gents' toilets	3	Presence detectors, alarms

3 a ▶8.3 **Students listen and answer the questions.**

Answers

See audioscript 8.3 on page 92

Answers

1 That the green attitude is shared by all the staff, so they would take care to switch off lights, etc. and so there is no need to control everything automatically
2 Instead of automating everything, they would have old-fashioned manual controls.
3 The advantage of operating the lights, etc. manually is that there's no need to supply all the automated controls with electricity. The money saved by not having to buy all the hi-tech gadgets could be spent on planting trees, for example.

b Students complete the task in pairs.

c Students complete the task in pairs.

Referring to measurable parameters

Language note

You will find the following vocabulary useful in this section.
consumption, cumulative, cycle, differential, flow, frequency, input, output, level, optimum, pressure, rate, temperature, timescale

Before you begin …
Ask students to explain what is meant by *measurable* (= can be *measured*).
Ask students to give some examples of things that are often measured in engineering and technology. You could look at the meaning of the following units of measurement.

˚C (degrees Celsius) = temperature
Pa (Pascals) = pressure
m^3 (cubic metres) = volume
m/s (metres per second) = speed/velocity
l (litres) = liquid capacity
l/s (litres per second) = flow/consumption
W (watts) = power
amp (amperes) = current
v (volts) = voltage / electromotive force

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4 **Students complete the task in pairs.**

Suggested answers

A thermostat measures and controls the water temperature in a boiler, and there is also sometimes a pressure sensor for safety. A thermostat measures and controls room temperature in a heating system. A refrigerator also has a thermostat to monitor and control the temperature and a light that is activated by the door opening. Washing machines have thermostats to control the temperature of the water inside the machine. The time of the wash cycle is also controlled. The action of the drum is linked to a safety device that prevents the door from being opened while the drum is spinning.

5 a **Students match the sensor or measuring system and the applications.**

Answers

1 e 2 b 3 a 4 d 5 c

b **Students complete the task in pairs.**

Answers

1 pressure measurement, for example monitoring the pressure of air inside a compressed air hose
2 temperature measurement, for example measuring the temperature of water in a boiler
3 flow, for example monitoring the amount of fuel flowing along a fuel pipe in an engine
4 level measurement, for example monitoring the level of fuel in a fuel tank
5 process recorders, for example monitoring the rejected (broken) items in a production process

6 a ▶8.4 **Students listen and answer the questions.**

Answers

a A blockage in a pipe causing a build-up of pressure
b A safety valve and a warning system triggered by a pressure differential
c A system for monitoring gas consumption
d Cumulative consumption, the rate of consumption at different points in time, and the frequency of peaks in consumption
e A timescale
f An exothermic reaction
g The temperature of gas at the input point, and at the output point
h The optimum input temperature for the gas

b **Students match the words and definitions.**

Answers

2 g 3 a 4 i 5 c 6 d 7 f 8 j
9 b 10 e

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c **Students complete the extract.**
You may need to explain *downstream* (= further down the direction of flow, for example in a river). It is used in engineering to describe industrial processes and the flow of liquid/air in pipe/duct networks – opposite = *upstream*.

Answers

2 consumption
3 cumulative
4 rate
5 timescale
6 cycle
7 frequency
8 input
9 output
10 optimum

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Audioscript 8.4 in more detail.
build-up = progressive increase, often describes pressure
vessel = closed tank which can hold a pressure greater than the atmospheric pressure outside it
safety valve = valve which opens and releases pressure if the pressure inside a vessel exceeds a safe level – designed to prevent an explosion
meter = measuring device
plot = draw a line on a graph
exothermic reaction = chemical reaction which produces heat
endothermic reaction = chemical reaction which absorbs heat

7 a **Students complete the task in pairs.**

Suggested answers

We need a meter/sensor to measure: the rate of flow of water at the input point; the water temperature at the input point; the rate of flow of gas at the input point; the temperature of the gas burner; the water temperature inside the vessel; the level of water inside the vessel; the steam pressure inside the vessel; the steam temperature inside the vessel; the steam temperature at the output point; the steam pressure at the output point; and rate of flow of steam at the output point.

b **Students complete the task in pairs.**

Suggested answers

The cumulative consumption of water and gas; the cumulative output of steam; the peak rates of consumption for water and gas; peak steam output; the frequency of gas use / firing of the burner; the differential between water input temperature and water temperature inside the vessel; the differential between steam pressure inside the vessel and in the output pipe; the differential between steam temperature inside the vessel and in the output pipe

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Discussing readings and trends

Language note

You will find the following vocabulary useful in this section.
band (of fluctuation), blip, continual, continuous, decrease, fall, fluctuation, increase, peak, range, rise, trough

Before you begin …
Ask students to explain what is meant by *reading,* for example a temperature reading on a thermometer, a pressure reading on a pressure gauge and *trend* (= *a pattern*). Explain that in order to explore readings and trends, you are going to look at electricity consumption and generation.

8 a **Students complete the task in pairs.**

Answers
See audioscript 8.5 on pages 92 and 93

b ▶8.5 **Students listen and make notes.**

Answers
1 temperature
2 light levels
3 day of the week
4 mealtimes
5 commercial breaks on TV

c ▶8.5 **Students complete the extracts and listen again to check their answers.**

Answers
1 increase
2 increases; decreases
3 rise
4 rises
5 falls
6 rise; fall

d ▶8.6 **Students listen and answer the questions.**

Answers
1 Because maximum capacity is equivalent to peak demand, there is significant spare capacity during off-peak periods.
2 Being able to generate power during off-peak periods and store it for peak periods
3 Because electrical charge is extremely difficult to store in large amounts

e **Students match the words and definitions.**

Answers
2 g 3 d 4 a 5 b 6 h 7 f 8 e

f **Students complete the task.**

Suggested answers
There is a band of fluctuation between approximately 2,700 and 5,000 Megawatts. Peak demand occurs each day at about 8.00 pm, when there is a very brief blip. The graph shows a trough each night, when demand falls significantly. At the weekend, the range of fluctuation is smaller than it is during the week. Fluctuations in demand are continual – there are no points where demand remains at the same level continuously for a long period of time.

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9 a **Students complete the extract.**

Answers

2 peak demand
3 continual
4 blips
5 fluctuations
6 range

b **Students read the extract and answer the questions.**

Answers

1 Operating on a start-run-stop-wait basis
2 Momentary blips in demand
3 Frequency of the AC (alternating current) supply
4 A slight drop in frequency indicates that power stations are working at full capacity.
5 Start-up of appliances is delayed slightly by holding the appliance on standby.

10 a **Students complete the task in pairs.**

Answers

1 Demand for electricity fluctuates, and power stations need to be able to cope with peak demand (at the top of the range of fluctuation). The problem is that the peak only lasts for a very brief period each day, meaning that power stations have a lot of generating capacity which, most of the time, is not used. Therefore, electric companies try to smooth demand – using spare capacity during demand troughs (at night) to store up energy, which is then used the next day when demand peaks.

b ▶8.7 **Students listen and make notes.**

c **Students complete the task in pairs.**

Extension activity: power stations (Resource sheet 8b)

Give students Resource sheet 8b. Students complete the extract.

Answers

2 nuclear
3 steam
4 water
5 reactor
6 rotors
7 pressure
8 rotary
9 generators
10 current
11 lake
12 reservoir
13 dam
14 gravity
15 hydrostatic

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Giving approximate figures

Language note

You will find the following vocabulary useful in this section.
ballpark figure, a good (more than), off the top of my head, pretty much, next to nothing, nowhere near, roughly, somewhere in the region of, the vast majority, well over

Before you begin …
Ask students to explain what is meant by *approximate numbers* (= opposite of precise numbers).
Tell students that this section will focus on approximate numbers using the example context of communication between engineers and managers.
Ask students to give examples of types of discussion that engineers and technical professionals might have that would involve using approximate numbers. You can use the underlined words as examples.

- When discussing the approximate dimensions of designs in the early stages of a design process.
- When estimating performance figures for ideas for technical solutions before detailed calculations are carried out.
- When speaking to non-technical colleagues who would be bored or confused by excessive detail.
- When summing up essential information where detailed numbers are not required.

11 a **Students read the extract and answer the questions.**

Answers

1 A senior manager
2 A review of the company's organisation and facilities
3 Optimising efficiency / the use of engineers' skills

b **Students match the questions and points.**

Answers

1 c 2 b 3 a

c ▶ **8.8 Students listen and make notes.**

Answers

1	A: 50%	B: 50%
2	A: 70%	B: 30%
3	A: 10%	B: 90%

d **Students complete the sentences.**

Answers

2 off the top of my head
3 pretty much
4 nowhere near
5 roughly / somewhere in the region of
6 roughly / somewhere in the region of

e **Students complete the task in pairs.**

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Extension activity: project management

The questionnaire in Exercise 11b raises the idea of engineers doing organisational/management tasks. Ask students whether they think the management of technical projects is a job best done by engineers who have subsequently become managers, or career managers who have some engineering knowledge. How much specialised technical knowledge do project managers need? The answer depends on the size and scope of the project being managed. An engineer with the relevant specialist knowledge may be the best manager on a specialised project based on a single technical discipline, for example developing more efficient photovoltaic cells for solar panels. But on a large project, for example the construction of a power station, the project manager would need to manage a multitude of specialised teams spanning electrical, mechanical and civil/structural engineering, and would therefore need to be more of a generalist, and more accomplished in management skills.

12 a ▶8.9 **Students listen and mark the statements True (T) or False (F).**

Answers

1 T
2 T
3 F – they print very few copies

b Students complete the task.

Answers

1 roughly
2 well over
3 a good
4 the vast majority
5 next to nothing

c Students complete the replies.

Answers

2 Pretty much
3 Nowhere near
4 Roughly / somewhere in the region of
5 Well over
6 Next to nothing
7 Roughly / somewhere in the region of
8 the vast majority

13 Students complete the task in pairs.

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Background information and useful web links

Describing automated systems (pages 62 and 63)

This section reflects the high degree to which modern devices, installations and processes are controlled automatically. Automation relies on close integration between the mechanical devices which are *controlled*, for example air-conditioning plant in buildings or robotic arms in factories, and the electronic devices and computer systems which *control* them. Consequently, *controls* (the collective name given to such systems) is an area in which mechanical and electrical engineers are required to work together closely.

Referring to measurable parameters (pages 64 and 65)

This section deals with the terms used to describe different parameters that can be measured by the sensors which send information to automatic control systems, and to the gauges and displays which can be monitored by human operators. An industrial process is used as an example context. However, the language is generically applicable to a broad range of engineering applications – vehicles, aircraft, power stations, kitchen appliances, and mechanical and electrical services in buildings are just a few examples.

Discussing readings and trends (pages 66 and 67)

This section extends the context of monitoring and measuring, to focus on the language of graphs which is useful for describing trends that can be observed from data recorded by various monitoring and control systems. The example context of electricity consumption trends, and the need to provide for peaks in demand, applies to all electricity grids. In the book, the UK is chosen as an example, as the phenomenon of demand spikes is particularly acute there, due to the proliferation of electric kettles (which are power-hungry) in British households. The daily peak, shown on the graph on page 66, occurs due to a mass kettle switch-on, as people make hot drinks when the credits roll at the end of one of Britain's most-watched TV shows – the soap opera *EastEnders*, on BBC1.

Pumped storage hydroelectric power stations
http://www.nationmaster.com/encyclopedia/Pumped-storage

Giving approximate figures (pages 68 and 69)

This section reflects the fact that, in spoken English, numbers are often given as approximate values. This applies as much to technical conversations as it does to general discussions.

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TEACHER'S NOTES

UNIT 8 Monitoring and control

Resource sheet 8a

a **Read the beginning of a novel about a gold bullion robbery from a bank vault. Underline the correct words to complete the text.**

CHAPTER 1

It was 2 am. The small room beneath the granite-walled bank was inky black, and silent but for the faint drone of the air vents that (1) **activated** / **regulated** its claustrophobic atmosphere. Not a single ray of light glinted off the golden trappings within. But if this was the darkest, quietest corner of the basement, the electronic (2) **senses** / **sensors** on the ceiling were wide awake, like the eyes of a nocturnal predator.

The eyes, technically speaking, were sensitive presence (3) **controls** / **detectors**, which functioned, not by (4) **sensing** / **triggering** light, but by measuring temperature. If they (5) **controlled** / **detected** an infra-red heat reading – human warmth – their electronic innards would be (6) **sensed** / **triggered** in an instant. The various circuits they (7) **controlled** / **detected** would then be activated, (8) **picking up** / **setting off** alarms. And the system was about to be tested.

The door burst open with a bang. As the echo reverberated, a thickset individual strode purposefully over the threshold. His presence was (9) **picked up** / **set off** in a millisecond. And a millisecond later, 16 stark lights blinked on. The man stopped in his tracks.

Once all the lights in the gents' toilets had come on, the security guard walked up to a washbasin, turned on the gold-anodized tap, and washed his hands. The nightshift was halfway through, and it was time for a sandwich.

b **Now answer the questions below.**

1 At first, which part of the bank does the author give the impression he's describing?
2 Which room in the bank is he actually describing?
3 What sensors and automatic controls are mentioned?

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TEACHER'S NOTES

UNIT 8 Monitoring and control

Resource sheet 8b

Use the words below to complete the textbook extract about power stations.

current dam ~~gas~~ generators gravity hydrostatic lake pressure nuclear reactor reservoir rotary rotors steam water

The main types of large-scale power station are coal-, oil- and (1) gas -fired stations, and atomic or (2) _____ power stations. All these types of station generate power using (3) _____ turbines. To drive the turbines, (4) _____ , usually pumped from a nearby river, is heated up by a nuclear (5) _____ , or by burning coal, oil or gas. The hot water generates a supply of steam, which is used to drive turbines – devices containing (6) _____ which spin when steam is channelled through them at high (7) _____ . The resulting (8) _____ motion is used to drive electrical (9) _____ , which produce alternating (10) _____ .

In a hydroelectric power station, water is channelled from a high-level (11) _____ (a natural water basin) or (12) _____ (a manmade water basin, built by civil engineers), down a hillside, or through the base of a (13) _____ (built to retain water behind it), at high pressure, by the downward force of (14) _____ . (Pressure generated by water pushing down from a higher level is called (15) _____ pressure.) The flow of water, under pressure, is channelled through turbines, which drive generators, as described above.

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UNIT 9 Theory and practice

- Explaining tests and experiments
- Exchanging views on predictions and theories
- Comparing results with expectations
- Discussing causes and effects

Go to page 114 for essential background information and useful web links.

Explaining tests and experiments

Language note

You will find the following vocabulary useful in this section.
back-to-back test, full-scale, reduced scale, in the field, computer model, scale model, mock-up, simulation, the acid test, trial run, tried-and-tested, validate, virtual (computer simulation)

Before you begin *…*
Ask students to explain what is meant by a *test* and an *experiment*. Ask students to give some examples of the types of test and experiment that engineers from different branches might carry out. You could use the example of the process that would be carried out by Airbus or Boeing when developing a new commercial passenger aircraft – computer modelling, testing of scale models in a wind tunnel, use of flight simulators, test flights, etc.

1 **Students complete the task in pairs.**

Suggested answers

1 Using software to simulate real-life situations. The main advantage of this technique is that testing is often faster and easier to undertake compared with real-life testing. Variables can also be changed easily. The main disadvantage is the lower degree of realism.
2 Testing small models of designs. The main advantage of this approach is that models are quicker and cheaper to build than full-sized prototypes. The main disadvantage is that their behaviour during tests cannot perfectly simulate that of a full-size prototype.
3 The main advantage of this approach is that tests are totally realistic. The main disadvantage is that full-scale prototypes can be expensive to build and test.

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2 a **Students complete the task in pairs.**

Answers

Computational Fluid Dynamics (CFD) is computer software used to assist in aerodynamic design. It models the flow of air over surfaces, such as car bodywork or the fuselage and wings of aircraft. Virtual testing with CFD software is typically done in the early stages of the design process. Wind tunnels equipped with rolling roads allow reduced-scale models of vehicles or full-size vehicles to be tested. Air is blown through the tunnel by powerful fans to create airflows of different velocities which simulate the vehicle travelling at different speeds. The airflow over the surfaces of the vehicle is highlighted with streams of smoke, so that it can be analysed. A rolling road is effectively a conveyor belt which moves beneath the stationary vehicle at the same speed as the airflow, making the wheels turn. This allows engineers to analyse the effects of the spinning wheels on the airflow. Field testing refers to testing in real conditions. For aerodynamic testing of a vehicle, this might involve driving the vehicle at different speeds on a circuit or runway.

Extension activity: aerodynamics (Resource sheet 9a)

Give students Resource sheet 9a. Students complete the extract.

Answers

2 gas	6 drag	10 power
3 motion	7 efficient	11 slippery
4 aerodynamic	8 turbulence	12 barn
5 wind	9 velocity	

b ▶9.1 **Students listen and answer the questions.**

Answers

1 Using a scale model or a full-size mock-up
2 To simulate the turbulence caused by wheels when they're spinning
3 Whether or not the wheels are mostly enclosed by the bodywork
4 They are not a hundred percent reliable; the data needs to be validated by full-scale tests in real conditions.
5 Changeable weather makes it difficult to do back-to-back testing.

c ▶9.1 **Students complete the extracts and listen again to check their answers.**

Answers

2 mock-up	4 acid test; tried-and-tested; trial run
3 validate	5 back-to-back testing; in the field

d **Students match the words and definitions.**

Answers

b tried-and-tested	f back-to-back testing
c in the field	g validate
d virtual	h trial run
e the acid test	

e **Students complete the task.**

Answers

2 e 4 d 6 a 8 b 10 c

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3 **Students complete the task in pairs.**

Answers

First, testing of the parachute could be done using a weight to simulate the mass of the container. The weight should be solid and unbreakable, for example a block of steel, to allow several parachute systems to be tested back-to-back without destroying the container each time. For tests, the weight and parachute could be dropped from a raised platform attached to a crane. Initially, the aim of these tests will be to develop a parachute system that will slow the container's fall as much as possible to minimise the vertical landing speed. Once the parachute system has been developed, and the vertical landing speed has been determined, tests can then be carried out on the container and deformable structure by simulating this known landing speed. Initially there will be no need to use the parachute, as the container can be allowed to freefall from the crane – the drop height being set so that the vertical landing speed is the same as that reached with a parachute. Initially, reduced-scale, for example half-size, mock-ups could be tested. Then full-scale tests can be carried out. The container design can then be tested with the parachute by dropping it from the crane. This will help to simulate the effects of the wind blowing the parachute and container, thus generating a horizontal (as well as vertical) landing speed. Finally, for the acid test, real-life trial runs can be carried out using an aircraft to validate the tests.

Exchanging views on predictions and theories

Language note

You will find the following vocabulary useful in this section.
arguably, assuming, presumably, surely, theoretically
Sure, Absolutely, Of course, I'm not so sure, I'm not convinced, Not necessarily

Before you begin **…**
Ask students to explain what is meant by *prediction* (= a forecast, trying to say/guess what *will* happen) and a *theory* (= an opinion or explanation) *in theory* (= it should be possible, but often doesn't happen that way) *in practice* (= in reality)

4 **a** **Students complete the task in pairs.**

Suggested answers

1 Humanitarian aid, for example food and medicine, and military equipment are often airdropped, as they frequently need to be delivered to remote locations with limited transport links.
2 The main advantage is that planes do not need to land and take off again to drop off cargo, saving time and fuel. The main disadvantage is the difficulty of protecting cargo from impact damage.

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b **Students complete the predictions.**

Answers

1 decrease – As long as the container remains in the air, its airspeed (its speed relative to the moving air in the atmosphere) will keep decreasing until it has an airspeed of zero – until it is travelling at the same speed and in the same direction as the wind. Therefore, if there is a certain amount of wind, the container will have a degree of groundspeed (horizontal speed relative to the ground), as it moves with the wind. If the aircraft is flying into the wind (in the opposite direction to the wind) when it drops the container, and if the container remains in the air long enough, the container will slow down until it momentarily has a groundspeed of zero. However, if it remains in the air beyond this point, its groundspeed will then begin to increase again in the opposite direction to the aircraft, as it is blown backwards by the wind.

2 higher – The container's vertical speed will keep increasing until, if it remains in the air long enough, it reaches *terminal velocity* – the point at which aerodynamic drag (air resistance) prevents it from travelling any faster.

3 and 4 This will depend on the shape of the container and the distribution of weight within it.

c ▶9.2 **Students listen and answer the questions.**

Answers

They agree on the first two points (horizontal speed decreases and vertical speed increases). They disagree on the last two points (which impact is worse, and what will happen on the ground with a very low-altitude drop).

5 a ▶9.2 **Students complete the extracts and listen again to check their answers.**

Answers

1 theoretically
2 assuming
3 surely
4 presumably
5 arguably

b **Students complete the task.**

Answers

1 Presumably
2 Assuming
3 Theoretically
4 Arguably
5 Surely

c **Students complete the task in pairs.**

Answers

Agree: Sure; Absolutely; True; Of course
Other phrases: I totally/completely agree
Disagree: I'm not so sure …; I'm not convinced; Not necessarily
Other phrases: I'm not sure I agree; I disagree; I totally disagree

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d **Students complete the task in pairs.**

Suggested answers

1 An aircraft's groundspeed is its speed relative to the ground. Its airspeed is the speed it passes through the air. Because of the wind, the air is usually moving. Therefore, if an aircraft is flying into the wind, its airspeed will be higher than its groundspeed. If it has the wind behind it, its airspeed will be lower than its groundspeed.
2 Zero
3 The aircraft would need to fly into the wind, and the wind speed would need to be very high, higher than the minimum speed required for the aircraft to fly.
4 It should fly into the wind so that the wind helps the container to slow down.
5 Provided the aircraft flies into the wind, higher wind speed will result in the container having a lower groundspeed on landing. However, above a certain wind speed, the container will reach zero groundspeed, then start to travel in the opposite direction. Beyond this point, even higher wind speeds will result in a higher groundspeed in the opposite direction.

Extension activity: airspeed and altitude

Ask students to explain how an aircraft's *altitude* affects its *airspeed*.

Answer

As altitude increases, the density of the air decreases (the air *gets thinner*). As a result, if an aircraft climbs progressively while travelling at a constant groundspeed (its speed relative to the ground), its *indicated airspeed*, shown on the cockpit *airspeed indicator*, will decrease, due to the reduced airflow as a result of the lower air density. This is why commercial aircraft climb to such high altitudes (30,000 to 40,000 feet = approx. 10,000 to 13,000 metres), as less power and consequently less fuel is required to propel the aircraft at high speed through *thinner* air.

6 a **Students complete the task in pairs.**

b **Students complete the task in pairs.**

Suggested answers

1 The container could be flat with a low centre of gravity so that it slides along the ground, or perhaps spherical with a deformable protective structure which allows it to roll along the ground.
2 The container could be tall, for example a cylinder shape, with a deformable protective structure at its base to absorb the vertical impact.

Comparing results with expectations

Language note

You will find the following vocabulary useful in this section.
anticipated / didn't anticipate, expected / didn't expect, went / didn't go exactly to plan, worked perfectly, (totally) exceeded (our) expectations, as it turned out, what actually happened, overestimated, underestimated, learned the hard way

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7 a Students complete the task in pairs.

Answers

Expectations are what you predict, for example how you think a vehicle prototype will behave when it's tested in a wind tunnel. Results are what actually happens, for example how the prototype actually behaves in the wind tunnel, based on the completed test.

b Students complete the task.

Answers

Trial and error means testing ideas to see what happens. The expression implies that the testing process is not very scientific, and is simply based on guesswork.
Unfamiliar territory means an unknown subject, an area where someone lacks experience.
On a steep learning curve means learning rapidly, often as a result of being put in an unfamiliar situation without the necessary knowledge or experience.

c Students complete the task.

Answers

See audioscript 9.3 on page 93

8 a ▶9.3 Students listen and answer the questions.

Answers

1 Half full
2 The opening in the bottle was just slightly bigger than the fitting at the end of the pump, so there was quite a good seal.
3 Quite powerful, more powerful than expected
4 The bottle tumbled over in the air – it wouldn't fly straight.

b Students complete the task.

Answers

1 thought/predicted
2 didn't expect/predict
3 it was much better than we had hoped

Before you begin …
You could use Resource sheet 9b to focus on some specific vocabulary that will be helpful during the discussion.

Answers

2 g 3 f 4 c 5 a 6 j 7 d
8 b 9 h 10 i

9 a Students complete the task in pairs.

b ▶9.4 Students listen and answer the questions.

Answers

They put a plastic beaker, with water inside it, onto the top of the bottle which made it front-heavy and increased its inertia.

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c ▶9.4 **Students listen again and complete the phrases.**

Answers
1 according to plan
2 a treat

10 a **Students complete the task in pairs.**

b ▶9.5 **Students listen, make notes and answer the question.**

Answers
See audioscript 9.5 on page 94

c **Students complete the definitions.**

Answers
2 practice
3 more
4 less
5 inadequate
6 practical

d **Students complete the task in pairs.**

11 **Students complete the task in pairs.**

Discussing causes and effects

Language note

You will find the following vocabulary useful in this section.
because of ..., cause ... to ..., consequently ..., due to ..., owing to ..., result in ..., as a result of ...

12 **Students complete the task in pairs.**

Suggested answers
1 Possible causes: the tyre is inadequately inflated or punctured
Possible effects: the tyre could blow out (explode) / the tyre will wear rapidly / become damaged
2 Possible causes: a surge in the power supply, too much power being demanded, a short circuit
Possible effect: a circuit breaker being triggered, overheating and damage to conductors and components
3 Possible cause: there is inadequate paint cover to protect the hull
Possible effect: the hull will degrade rapidly / could fail

13 a **Students complete the task in pairs.**

Answer
A mistake with a chicken gun has made clever, technical people look like fools.

b **Students read the article and answer the questions.**

Answers
1 To fire dead chickens in order to test aircraft engines and windshields for their resistance to bird strikes
2 Because it was a high-speed train and bird strikes were a potential danger
3 The chicken broke through both the windshield and the back of the driver's compartment.

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c **Students answer the questions.**

Answer

They used a frozen chicken.

d **Students complete the sentences.**

Answers

2 because of; due to; owing to
3 result of
4 because of
5 caused
6 consequently

e **Students complete the descriptions.**

Answers

1 because of / due to / owing to
2 caused; consequently
3 because of / due to / owing to; resulted in; consequently

14 **a** **Students complete the task in pairs.**

Answers

See audioscript 9.6 on page 94

b ▶9.6 **Students listen and compare the points made with their answers in Exercise 14a.**

c **Students complete the task in pairs.**

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Background information and useful web links

Explaining tests and experiments (pages 70 and 71)

This section focuses on technical experimentation and development. The context of aerodynamic design exemplifies the language used to describe the range of development tools used by engineers in all disciplines – from computer modelling, through reduced-scale testing, to full-scale field trials.

Wind tunnel testing
http://www.youtube.com/watch?v = ZiP-6YHIUnw

Exchanging views on predictions and theories (pages 72 and 73)

This section is based on the fact that making theoretical predictions about how designs will perform in practice can be a subjective area. The context of predicting how an airdropped cargo container will behave on hitting the ground is chosen as an example of an unpredictable situation, providing a basis for subjective discussion and disagreement.

Comparing results with expectations (pages 74 and 75)

This section follows on from *predictions and theories*, covered in the previous section, to focus on comparing what was predicted (expectations) with what actually happened (results).

Water rockets
http://www.wra2.org/
http://www.youtube.com/watch?v = rrWnqoJs_KQ&feature = related

Discussing causes and effects (pages 76 and 77)

Having focused on *predictions and theories* (from discussions before tests and experiments take place) and *comparing results with expectations* (discussing how tests turned out), we now move on to discussing the *reasons* for the results of tests, by looking at the language used to relate to *causes and effects*. This is clearly important language in many aspects of engineering, from developing new devices and technologies to trouble-shooting existing devices and installations.

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TEACHER'S NOTES

UNIT 9 Theory and practice

Resource sheet 9a

Use the words below to complete the textbook extract about fluid dynamics.

aerodynamic door drag efficient gas ~~liquid~~ motion power slippery turbulence velocity wind

In everyday English, the word *fluid* is used to describe (1) liquid substances. In physics and engineering, a fluid can be either a liquid or a (2) _____ . *Fluid dynamics* refers to the study of fluids in (3) _____ i.e. how they behave when they move, or when objects are moved through them.

One of the major applications of fluid dynamics is in (4) _____ design – the study of how objects affect / are affected by a flow of air, either when moving through the air, or when subjected to a flow of air – e.g. due to the (5) _____ blowing around them. One of the main considerations in aerodynamics is assessing how much (6) _____ (air resistance) a vehicle or aircraft generates as it moves through the air. Designs that generate very little drag are said to be aerodynamically (7) _____ . In general terms, minimizing drag means having a shape which allows air to flow around it as 'cleanly' as possible – i.e. with minimum (8) _____ (disruption to the airflow).

Generally, the faster a vehicle or aircraft is designed to travel, the more critical its aerodynamic design will be. This is because, for a given increase in (9) _____ (speed), there is a proportionately much greater increase in drag. Due to this phenomenon, when vehicles or aircraft travel extremely fast, they must deliver significantly more (10) _____ in order to increase their velocity by a relatively small amount.

In familiar language, engineers often describe aerodynamically efficient designs as being (11) '_____', inferring that they 'slide' through the air easily. In the automotive industry, aerodynamically inefficient cars are often described as being 'like a barn (12) _____'.

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UNIT 9 Theory and practice

Resource sheet 9b

The terms in 1–10 are useful for describing the behaviour of rockets. Match them to the definitions in a–j.

1 blast-off	a an object's resistance to acceleration or deceleration, increases as the mass of the object increases
2 drag	b describes an object which has the highest proportion of its mass located towards its upper end
3 in freefall	c downward force exerted by the earth's mass
4 gravity	d a pushing force
5 inertia	e the moment a rocket launches from the ground
6 powerless	f descending towards the ground, with no force counteracting the descent except aerodynamic resistance
7 thrust	g aerodynamic resistance
8 top-heavy	h the path taken by a moving object
9 trajectory	i the way the total mass of an object is divided/positioned within the volume of the object
10 weight distribution	j has no means of propulsion

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UNIT 10 Pushing the boundaries

- Discussing performance and suitability
- Describing physical forces
- Discussing relative performance
- Describing capabilities and limitations

Go to page 125 for essential background information and useful web links.

Discussing performance and suitability

Language note

You will find the following vocabulary useful in this section.
adequate/inadequate, appropriate/inappropriate, consistent/inconsistent, economical/uneconomical, effective/ineffective, cost-effective, efficient/inefficient, reliable/unreliable, sufficient/insufficient, suitable/unsuitable

Before you begin **…**
Ask students to explain what is meant by *pushing the boundaries* (= trying to do things that have never been done before). Ask for some examples of engineering projects that have pushed the boundaries. Ask students to explain what is meant by *performance* (= how well something performs) and *suitability* (= how suitable something is for the job). Explain that to explore questions of performance and suitability this section looks at the design of wind turbines.

1 a **Students complete the task in pairs.**

Suggested answers

1 They use the kinetic energy, movement of the wind, to generate electricity.
2 Advantage: They use a renewable, non-polluting energy source that is readily available.
Disadvantages: The wind is not constant, so wind turbines cannot function all the time. They also have a major visual impact due to their height and size, and are relatively noisy.
3 Locations exposed to the wind, such as high ground, flat areas and coastal areas

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b **Students complete the task in pairs.**

Suggested answers

The blades turn due to the airflow generated by the wind. To function, they need to have a specially designed aerodynamic profile. They must also be stiff, to avoid flexing and consequently hitting the tower, and relatively light to allow them to turn easily.
The tower must be rigid, to resist the bending force generated by the pressure of the wind. It must also have a relatively narrow profile, to minimise the aerodynamic effect it has on the blades. When a blade is in the low position, aligned with the tower, the pressure of the wind on the blade is reduced, reducing effectiveness, and causing torsion in the turbine due to differential pressure on the higher and lower blades.
The turbine generates electricity from the action of spinning. To function effectively, it needs to minimise friction. It must also resist the severe weather which is common in the areas where wind turbines are located.

2 a ▶ **10.1 Students listen and answer the questions.**

Answers

1 The tower
2 Corrosion due to the presence of saltwater
3 Steel and reinforced concrete
4 Because in reinforced-concrete coastal defences, the steel reinforcement is often exposed, due to erosion, and rusts as a result
5 That just because an installation requires regular maintenance, that doesn't necessarily mean it's unreliable
6 A comparison of the difference between the construction cost of a reinforced-concrete tower and the cost of repainting a steel tower over the period of a concrete tower's lifespan

b **Students match the words and definitions.**

Answers

1 b 2 e 3 c 4 a 5 f 6 d

Pronunciation focus

Ask students to underline the stressed syllable in the following words and practise saying the words.

adequate, appropriate, consistent, economical, effective, cost-effective, efficient, reliable, sufficient, suitable

c **Students complete the task.**

Answer

2 inappropriate
3 inconsistent
4 uneconomical
5 ineffective
6 inefficient
7 unreliable
8 insufficient
9 unsuitable

d ▶ **10.1 Students listen again and answer the question.**

Answers

See audioscript 10.1 on page 94

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Extension activity: language from Exercise 2b (Resource sheet 10a)

Give students Resource sheet 10a. Students complete the conversations.

Answers

2 inappropriate	6 effective	10 uneconomical
3 sufficient	7 unreliable	11 reliable
4 ineffective	8 inefficient	12 efficient
5 insufficient	9 cost-effective	

3 a **Students complete the extract.**

b **Students complete the task in pairs.**

Describing physical forces

Language note

You will find the following vocabulary useful in this section.
bending, centrifugal force, compression, contraction, expansion, friction, pressure, shear, tension/torque

Before you begin …
Ask students to explain what is meant by *force* (= a push or pull). What effect do forces have on objects? They cause them to *move*, *deform* (= change shape or both). Explain that to explore different types of force that are fundamental in engineering, this section looks at an unusual project being planned in Australia which aims to push the boundaries in both structural engineering and green energy.

4 a **Students read the article and answer the question.**

b **Students answer the question. At this stage, they could describe the forces using non-technical language, for example *crushing, stretching, sliding, twisting, wobbling*.**

c ▶10.2 **Students listen and answer the question.**

Answer

She doesn't mention centrifugal force.

d **Students label the diagrams.**

Answers

2 bending	7 shear
3 torsion/torque	8 friction
4 expansion	9 contraction
5 pressure	10 centrifugal force
6 tension	

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e ▶10.2 **Students complete the extracts and listen again to check their answers.**

Answers

2 pressure
3 bending
4 compression; tension
5 shear
6 friction
7 torsion (torque)
8 expansion; contraction

f **Students complete the task in pairs. Resource sheet 10b accompanies the diagram on page 81 to help students with the task.**

Extension activity: forces (Resource sheet 10c)

Resource sheet 10c is a further consolidation exercise on forces.

Answers

2 mass	6 magnitude	10 compress
3 accelerate	7 area	11 elongation
4 velocity	8 stress	12 strain
5 gravity	9 deform	

Discussing relative performance

Language note

You will find the following vocabulary useful in this section.
consideration, criterion/criteria, factor, variable
by a ... margin, to a ... extent, by a ... amount
considerably, marginally, much (more/less), significantly, slightly, substantially

Before you begin ...
Ask students to explain what is meant by *relative* (= compared with something else). Explain that to focus on the language used when describing relative performance in engineering applications, this section looks at high-speed trains.

5 a **Students complete the task in pairs.**

Suggested answers

Planes travel much faster than high-speed trains. The fastest high-speed trains can travel at just over 300 km/h. Commercial aircraft flying at an altitude of around 30,000 feet can travel with a groundspeed of around 800 km/h. Therefore, on board trips are typically faster on planes. However, rail networks generally link city centres, which are often more convenient destinations than out-of-town airports. Planes also tend to be delayed more often than trains, due to air traffic congestion at airports. Large aircraft cannot take off and land immediately after one another due to the need for separation distances for safety, and to allow air turbulence time to clear along the runway after each take-off and landing. Also, checking in for flights takes longer than boarding trains. For these reasons, overall journey times on high-speed trains can be as short as, or shorter than, those on planes over distances of 500 km to 1,500 km.

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b **Students read the article and answer the questions.**

Answers

1 Speed, convenience, efficiency and environmental-friendliness
2 To find the best way of transporting people
3 That high-speed electric trains are the most efficient solution

c **Students complete the task.**

Answers

1 criterion
2 factor
3 variable

6 a **Students answer the questions.**

Answers

Most TGVs reach 300 km/h. Newer models run at 320 km/h on certain tracks. Most trains are approximately 200 metres long.

Note

TGV stands for *Train à Grande Vitesse* (*Train* = train, *Grande Vitesse* = high speed).

b **Students complete the task.**

Answers

See audioscript 10.3 on page 95

c ▶**10.3** **Students listen and answer the questions.**

Answers

1 It was modified to a certain extent but, with a few exceptions, was essentially an ordinary TGV.
2 100 metres
3 To make it slightly more aerodynamic
4 To reduce the speed of revolution, to limit friction and centrifugal force

d **Students listen again and complete the table.**

Answers

2 – 50% 3 – 15% 4 + 19% 5 + 68%

Before you begin …
Look at the meaning of the following terms.

catenary = downward curved line of a cable when suspended between two supports
oscillation = wave pattern
camber = angle that is inclined from horizontal, usually at 90 degrees to the direction of travel, for example the camber of a road is the slope of the road across its width (sometimes also called *banking*)

e **Students rewrite the sentences.**

Answers

2 certain
3 significantly
4 slightly more
5 marginally
6 substantially
7 considerable

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f **Students complete the task.**

Suggested answers

1 The supply voltage in the catenary cables had to be increased by a considerable amount.
2 To limit oscillation, the tension of the catenary cables was substantially increased.
3 The camber of the track was increased marginally on some curves.
4 The previous record was beaten by a huge margin.
5 In perfect conditions, the TGV could probably have gone slightly faster.

7 **Students complete the task in pairs.**

Describing capabilities and limitations

Language note

You will find the following vocabulary useful in this section.
able/unable to, capable/incapable of ...ing, cope with, exceed, intended for, subjected to, surpass, withstand

Before you begin ...
Ask students to explain what is meant by *capabilities* (= what things can do / are *capable of doing*), for example how much force a column *is capable of* carrying, how much power an engine *is capable of* producing and *limitations* (= the limits of capability).

8 a **Students read the extracts and answer the questions.**

Answers

See audioscript 10.4 on page 95

b ▶10.4 **Students listen and check their answers to Exercise 8a.**

Before you begin ...
Check students' understanding of G-force and discuss some examples.

G-force is an *acceleration* or *deceleration* force measured relative to the force of *acceleration due to gravity*. An acceleration of 1G is equivalent to the acceleration of an object, due to gravity, as it *freefalls* towards the earth. Acceleration due to gravity is 9.8 m/s² (= an increase in speed of 9.8 metres per second every second). For example, a sports car is considered pretty powerful if it can accelerate from 0 to 100 km/h in 4 seconds. 100 km/h = approx. 28 m/s. To reach a speed of 28 m/s in 4 seconds, the car must increase its speed (accelerate) by 7 m/s every second (7 m/s x 4 seconds = 28 m/s). As 9.8 m/s² = 1G, 7 m/s² = 7/9.8 = 0.7 G s. Formula 1 cars, under full braking, can produce deceleration forces of up to 5 Gs. In military fighter aircraft, which can produce extreme G-forces, pilots risk blacking out if they are subjected to forces above 7 Gs. You could compare these figures with the G-forces in the *Sonic Wind* tests.

c **Students complete the task.**

Answers

1 1,015
2 3
3 20
4 1.2
5 46

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d ▶10.5 **Students listen and check their answers to Exercise 8c.**

e **Students complete the groups of synonyms.**

Answers

2 cope with; withstand
3 exceed; surpass
4 intended for
5 able to; capable of
6 incapable of; unable to

f **Students complete the sentences.**

Answers

Key information and questions

The supersonic rocket sled ride for tourists is to be located in the Australian desert. It is to carry a pilot and two passengers. It must avoid extremes of G-force under acceleration and deceleration (max 2 G). Max track length 16 km. Is it feasible to have just 10 km of track? Is that enough safety margin? Is the sled to have steel skids or wheels? Propulsion will be by rocket or jet engine (being looked into by someone else). Braking system – not a water brake, as there is too much G-force; possibly a friction system (against rails), an aerodynamic system (flaps or parachutes), reverse engine thrust system or a combination of these.

Extension activity: more vocabulary

You could look at the meaning of some of the terms in Exercise 9b in more detail.
sled = vehicle that slides along, i.e. does not have wheels, for example a sled designed to travel over snow
supersonic = faster than the speed of sound
skids = plates designed to slide along the ground or rails
derailing = coming off the rails
aerodynamic lift = upward, lifting force generated by a flow of air
flaps = movable aerodynamic panels – note that in aircraft, flaps generate *drag* and *lift*, and *spoilers/airbrakes* generate *drag* and *downforce*, therefore *spoilers/airbrakes* would be a more suitable term in the case of the rocket sled
reverse(d) thrust = thrust directed in the opposite direction to that in which a vehicle/aircraft is travelling, intended to slow the vehicle/aircraft

9 a **Students read the extract and make notes.**

b **Students complete the task in pairs.**

c ▶10.6 **Students listen and compare the points made with their answers in Exercise 9b.**

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Note

The required track length has arguably been underestimated both in the email, and by the engineers. It is being assumed that the acceleration of the sled will be more or less constant from a standstill, up to and through the sound barrier. However, the degree of aerodynamic drag encountered towards the sound barrier is significantly higher than at slightly lower speeds, and will limit the acceleration of the sled substantially during the final push through the sound barrier. If the sled spends time labouring at speeds just below the sound barrier, as it tries to touch supersonic speed, it will end up covering a substantial distance, arguably requiring a much greater track length.

d **Students complete the task in pairs.**

e **Students complete the task in pairs.**

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Background information and useful web links

Discussing performance and suitability (pages 78 and 79)

This section is based on the fact that, in order to find solutions to technical problems/requirements, choices need to be made. This might involve choosing the most appropriate materials for making products, choosing among standard components available from different suppliers, choosing the most efficient assembly/manufacturing procedure, etc. The communication surrounding choices of this type centres on issues such as appropriateness/suitability, effectiveness, efficiency, reliability, etc. The language used to discuss these issues is therefore the focus of this section.

Describing physical forces (pages 80 and 81)

Analysing different types of physical force plays a fundamental role in engineering design. The specific context of this section – tall structures – is chosen as being useful for exemplifying the main forces. However, the same forces are relevant throughout the various branches of mechanical and civil/structural engineering, and the study of forces is a core subject in all engineers' education.

Enviromission solar tower
http://www.enviromission.com.au/SolarTower%20Animation%20Metric.wmv

Discussing relative performance (pages 82 and 83)

This section focuses on making qualified comparisons, by exploring performance differentials. The context, the in-service passenger train world speed record, set by the TGV, uses the example of comparing the configuration of standard technology with that of modified technology.

TGV record
http://fr.youtube.com/watch?v = 8yszy1wltw8&feature = related

Describing capabilities and limitations (pages 84 and 85)

This section focuses on engineering technology at the limits of its performance capabilities. The context of the *Sonic Wind* tests is an extreme example, representing an engaging topic. However, the limits of performance are an everyday issue in engineering, particularly in design, where the maximum capabilities of components and assemblies must be established through calculations, in order to determine suitable *factors of safety* – the extent to which things are *overdesigned* in order to be able to cope with extreme conditions without *failing*.

The John Paul Stapp story
http://www.ejectionsite.com/stapp.htm

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TEACHER'S NOTES

UNIT 10 Pushing the boundaries

Resource sheet 10a

a **Complete the conversation using the words in the box.**

An interior designer is talking to a structural engineer.

~~appropriate~~	effective	inappropriate	ineffective	insufficient	sufficient

Designer: One idea I've had, as a design feature on the concrete columns, is to have a really rough finish on the surface, with the steel reinforcement partly exposed in places, so it's visible. I don't know if it would be OK to do that – whether it would be (1) appropriate , technically. I'm only talking about the columns inside the building. It would obviously be (2) _____ to do that with the ones outside, otherwise the steel would rust.

Engineer: Yeah. It would also be a problem inside, actually, with fire regulations. You have to have (3) _____ thickness of concrete covering the steel, to protect it against fire.

Designer: Oh, right. I didn't realise steel could catch fire.

Engineer: Well, it doesn't actually catch fire. But when it gets hot, it just goes like rubber – structurally, it becomes totally (4) _____ . So if there's (5) _____ cover, then ...

Designer: The building falls down.

Engineer: That's right. I mean, you can get a special type of fire-resistant paint, called intumescent paint. But you need to put on quite a thick coat to make it (6) _____ . So you wouldn't see the steel through it. And it's not really designed for that purpose.

Designer: OK, not to worry. It was just an idea.

b **Complete the conversation using the words in the box.**

An engineer at a power station is talking to a manager.

cost-effective	efficient	inefficient	reliable	uneconomical	unreliable

Engineer: Given the age of these gas turbines, you'd think they would be breaking down all the time – starting to get (7) _____ . But that's not the case at all. They're performing perfectly well. The problem is, in terms of energy consumption, compared with modern equivalents they're just very (8) _____ . So financially speaking, it's just not (9) _____ to keep running such (10) _____ equipment.

Manager: So we need to look at replacing them with a more economical solution before they reach the end of their planned lifespan? That's basically what you're saying?

Engineer: I think we have to, yes. If we wait until they break down, we'll still be using them in 50 years' time. In a sense, you could say they're too (11) _____ .

Manager: OK. And in terms of energy consumption, how (12) _____ would a new installation be, comparatively?

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TEACHER'S NOTES

UNIT 10 Pushing the boundaries

Resource sheet 10b

You can use these notes to help you with Exercise 4f on page 81.

Structural evaluation with NO WIND FORCES

Structural component	Forces acting on component
Column 1	
Leg 1	
Leg 2	
Beam	
Column 2	
Leg 3	
Leg 4	
Concrete foundations	
Pivoting insulators	
Conductors	

Structural evaluation for WIND DIRECTION 1

Structural component	Forces acting on component
Column 1	
Leg 1	
Leg 2	
Beam	
Column 2	
Leg 3	
Leg 4	
Concrete foundations	
Pivoting insulators	
Conductors	

Structural evaluation for WIND DIRECTION 2

Structural component	Forces acting on component
Column 1	
Leg 1	
Leg 2	
Beam	
Column 2	
Leg 3	
Leg 4	
Concrete foundations	
Pivoting insulators	
Conductors	

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UNIT 10 Pushing the boundaries

Resource sheet 10c

Use the words below to complete the textbook extract about the effects of forces.

accelerate area compress deform elongation gravity magnitude mass strain stress ~~unit~~ velocity

The (1) unit of force is the newton (N). One newton is equal to the force required to cause a (2) _____ of 1 kilogram (kg) to (3) _____ at 1 metre per second per second (m/s^2). For example, if an object with a mass of 1 kg is floating in space, and is pushed by a constant force of 1 N, the (4) _____ (speed) of the mass, measured in metres per second (m/s), will increase by 1 m/s every second (= 1 m/s^2). On earth, (5) _____ exerts a downward acceleration of approximately 10 m/s^2. Therefore, on earth, a 1 kg mass is subjected to a downward force of approximately 10 N, a 2 kg mass to 20 N, and so on.

The effect a force has on an object, such as a column in a building, depends on the (6) _____ of the force (how great the force is). It also depends on the size of the object – so for a column, how thick it is, or more precisely, what its cross-sectional (7) _____ is. If the same force is applied to two columns with different-sized cross-sections, the thinner column will have a harder time, as the force will be more concentrated. The degree to which force is concentrated (the measurement of force divided by area) is called (8) _____ , and is measured in Pascals (P), the unit of pressure.

When subjected to stress, an object will either move (e.g. slide or sink), (9) _____ (change shape), or do both. In a column in a building, for example, an applied stress will tend to cause the column to (10) _____ (squash) slightly – though this deformation will be very slight, and invisible to the eye. In engineering, a change in shape due to the effects of stress, such as compression (decreasing in length) or (11) _____ (increasing in length), is called (12) _____ .

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